Human Capital Accounting in the United States:
Context, Measurement, and Application

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Abstract

This study updates Christian's (2010) human capital account for the United States to the year 2009, refining the underlying data and putting the account into international context by reviewing applications in the rest of the world. It also measures the sensitivity of human capital measures to alternative assumptions about income growth rates, discount rates, the treatment of taxes, smoothing and imputation of labor force and school enrollment data, and the valuation of non-market time. It concludes with an application to the measurement of the output of the education sector.

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I. Introduction

Research in human capital has experienced a resurgence over the past several years, with human capital accounts having been produced recently in Australia, Canada, China, Finland, New Zealand, Norway, Sweden, the United Kingdom, and the United States. Christian's (2010) account for the United States, using an approach based on that of Jorgenson and Fraumeni (1989, 1992), measured the human capital stock and human capital investment in both nominal and real terms over the period between 1994 and 2006. The account broke down net human capital investment among five components: investment from births, depreciation from deaths, investment from education net of the aging of enrolled persons, depreciation from the aging of non-enrolled persons, and a residual component that takes into account both migration and measurement error.

The discussion below adds to the work in Christian (2010) in three ways. First, it puts the results for the United States in international context by reviewing recent efforts in human capital around the world. Second, it updates the results to 2009 to reflect both the availability of new data and improvements to the data set using previously existing data. Third, it investigates the sensitivity of the results to alternative approaches to accounting for discounting and income growth, the measurement of taxes, the smoothing and imputation of data, and the classification of nonmarket activities as production.

A review of recent work finds that most work in human capital has focused on income-based approaches, particularly approaches based on lifetime income in the vein of Jorgenson and Fraumeni (1989, 1992). Using a lifetime income approach and assuming an income growth rate of 2 percent and a discount rate of 4 percent, the human capital stock of the United States in 2009 was equal to about three quarters of a quadrillion dollars, split between market and non-market components by a ratio of about one third to two thirds. Net investment in human capital from education, net of the aging of persons enrolled in school, was equal to $7.0 trillion, split about evenly between its market and nonmarket components. The market component alone, equal to $3.7 trillion, is larger than the size of the education sector in the U.S. national accounts by a factor of about four. While levels of human capital often change substantively with changes in the assumptions of the model, real growth in net investment in education, equal to 1.6 percent per year across both the market and nonmarket components, is quite robust to changes in the income growth rate, the discount rate, the treatment of taxes, the approach to smoothing and imputation, and the definition of nonmarket work.

II. Recent Efforts in the Measurement of Human Capital

Le *et al* (2003) identifies three major approaches to measuring human capital: the cost-based approach, the income-based approach, and the educational-stock-based or indicators approach. This distinction has sufficient currency that it also appears in Liu and Greaker (2009), Gu and Wong (2010a), Li *et al* (2010), and Jones and Chiripanhura (2010). The indicators approach is the simplest; it uses an indicator or combination of indicators, such as years of schooling or the rate of literacy, to measure a country's human capital. The cost-based approach values the human capital stock at the cost of producing it. A frequently cited text on the cost-based method is Kendrick (1976), which measures human investment using the cost of rearing children, educating people, and other human-capital-related activities. A recent application of the cost-based approach is Kokkinen (2008), which estimates human capital in Finland.

The income-based approach values the human capital stock using the earnings of the persons in that stock. Jorgenson and Fraumeni (1989, 1992), which measure human capital using lifetime incomes in present discounted value, are seminal applications of the income-based approach. The income-based approach has been the most popular approach in recent applications, having recently been employed to create human capital measures for China (Li *et al*, 2010), the United States (Christian, 2010), the United Kingdom (Jones and Chiripanhura, 2010), Canada (Gu and Wong, 2010a), Australia (Wei, 2004, 2008), New Zealand (Le *et al*, 2006), Sweden (Ahlroth *et al*, 1997), and Norway (Liu and Greaker, 2009). The income-based approach is also being used for the human capital project at OECD, which aims to produce human capital accounts across eighteen countries for international comparisons (Mira and Liu, 2010). Abraham (2010) identifies the cost-based approach and the income-based approach as analogous to the income and production sides of a national income and product account but notes that, unlike the two sides of a national income and product account, cost-based and income-based human capital accounts should not necessarily lead to identical results.

Many implementations of the income-based approach limit the data set to the working-age population, to persons in the labor force, or to employed persons only. This limitation is described in Jones and Chiripanhura (2010) as "consistent with the OECD's guidance on the measurement of physical capital which states that, 'be counted as part of the capital stock all that is required is that assets are present at production sites and capable of being used in production or that they are available for renting by their owners to producers'." A human capital measure that is limited to the working-age population is denoted in Li *et al*'s (2010) paper on China as "active human capital", since it is the human capital of people who are active in the labor force. Active human capital is measured in Gu and Wong's (2010a) study of Canada (working-age population), Le *et al*'s (2006) study of New Zealand (employed persons), Jones and Chiripanhura's (2010) study of the United Kingdom (employed persons), and Liu and Greaker's (2009) study of Norway (persons in the labor force). Wei's (2004) account for Australia presents results for both the working-age population as a whole and for people in the labor force only, and finds that the human capital stock for people in the labor force is about 80 percent the size of the human capital stock for the entire working-age population. Christian's (2010) paper on the United States, Ahlroth *et al*'s (1997) paper about Sweden, and Li *et al*'s (2010) paper on China include results for the entire populations of the countries studied.

Most recent work focuses on the market component of human capital, which, under the income approach, is the component of human capital that is attributable to the value of a population's market work. The other component of human capital in Jorgenson and Fraumeni (1989, 1992), the nonmarket component, is attributable to the value of a population's nonmarket time. In some applications, the non-market component is excluded, sometimes purposefully under the premise that the market component alone is the preferable measure of human capital. For example, Le *et al*'s (2006) paper about New Zealand states that "assuming equal value between a full-time worker and a non-participant is not justifiable, from an economic point of view." (See also Ervik *et al*, 2003; and Gu and Wong, 2010a.) Non-market human capital is included in Christian's (2010) paper about the United States and Ahlroth *et al*'s (1997) paper about Sweden.

Education is measured in the Jorgenson-Fraumeni approach using the number of years of education received. In the original Jorgenson and Fraumeni (1989, 1992) papers, people were classified as having between 0 and 18 years of education. This approach was particularly well-suited for the demographic data available in U.S. Census data at the time, which measured education levels in the U.S. population in the same way. Most of the more recent work in human capital outside of the United States, however, has used data that measures education levels using qualifications earned (perhaps in part because of the existence of multiple educational tracks), and it is typically the case that these qualifications require more than a year to complete. As a result, many researchers outside the United States have adapted the Jorgenson-Fraumeni method to accommodate the circumstances in the country in which human capital is being measured. For example, Wei's (2004, 2008) account for Australia classifies people into four educational qualification groups: unqualified, skilled labor, bachelor degree, and higher degree. In the United States, the Census education variables changed in 1992 from individual years to degrees earned, although it is possible to recover individual years from the basic Current Population Survey starting in 1997 (see Jaeger, 1997, 2003). Christian's (2010) study of human capital in the United States imputed individual years of education.

One interesting difference that appears among studies is in approaches to deflating the stock of human capital over time to make comparisons across time possible. In some cases, the human capital stock is deflated using a consumer or labor price index (Wei, 2004, 2008). Under this approach, changes in lifetime incomes relative to changes in prices remain after deflation. If human capital accounts purport to measure human capital stocks and investments as quantities, this approach implies that changes in real lifetime incomes reflect changes in the quality of human capital within age, sex, and education levels. In other cases, the human capital stock is deflated using prices for human capital itself, eliminating changes in lifetime incomes and leaving a quantity index based entirely on the number and distribution of persons by age, sex, and education (Gu and Wong, 2010a; Christian, 2010). The quality of human capital within age, sex, and education level is implicitly presumed to be constant over time.

Several different approaches to disaggregating changes in the quantity of human capital from one year to the next into investment and depreciation are employed. Wei's (2008) disaggregation for Australia is especially novel, identifying (among several other things) human capital formation from post-school education and on-the-job investment, as well as depreciation of human capital formed by post-school education and on-the-job investment. Many human capital studies focus entirely on the stock of human capital and do not attempt to measure investment or depreciation.

Human capital accounting has particularly interesting applications for the measurement of the education sector. This application is specifically mentioned in the Atkinson (2005) report, which sets an agenda for measurement in the United Kingdom. Ervik *et al* (2003) is an interesting application of human capital in that it focuses on the output of the education sector, to the extent that it does not present a measure the stock of human capital. The authors find that the higher education sector in Norway is more than seven times larger when measured using the Jorgenson-Fraumeni methodology for human capital investment than when measured as it was in the Norwegian national accounts. Christian (2010) similarly finds very large values for investment in education in the United States. In contrast, Ahlroth *et al* (1997) find measures of investment in education in Sweden that are often smaller than those measured in the Swedish national accounts.

Several applications of the income-based approach to human capital use measures of income other than lifetime income to value human capital. Haveman *et al* (2003) uses a measure of human capital denoted "earnings capacity", which measures the value of the human capital stock as the expected income in a single year of all working-age persons in an economy if all persons worked full-year full-time. Earnings capacity is a measure of the potential annual rental value of human capital, in contrast to the asset value measured by the Jorgenson-Fraumeni approach. Since earnings capacity is based on current income (or, more accurately, potential current income, were persons working full-time full-year) rather than lifetime income, it does not require assumptions about the discount rate or income growth rate to produce. O'Mahony and Stevens (2009) present a measure of the output of the education sector that aggregates enrollments across multiple levels of education using a weight based on the effects on earnings from completing each level of education.

III. Updated Measures for the United States

Updates of the human capital measures for the United States presented in Christian (2010) are presented in Table 1 below for 2009 and for the each year between 1998 and 2009 in the Appendix. The update introduces results for three more recent years (2007, 2008, and 2009), and also incorporates changes to the data set since Christian (2010). Both the account in Christian (2010) and this updated human capital account measure human capital by applying a method broadly similar to the Jorgenson-Fraumeni approach. The data set from which the account is produced uses the October school enrollment supplements to the Current Population Survey (CPS) to measure population and school enrollment, the March demographic supplements to the CPS to measure wages and hours worked, and the life tables of the Centers for Disease Control to measure survival rates. The account includes all persons, whether working-age or not, with age topcoded at 80 and years of education topcoded at 18. When measuring lifetime incomes in present discounted value, an annual income growth rate of 2 percent and a discount rate of 4 percent is used. Measures of real growth are measured using quantity indexes of the population by age, sex, and education; consequently, all real growth measures are determined entirely by changes in the size and distribution of the population by age, sex, and education. The account is discussed in further detail in Christian (2010), with changes between the earlier account and the updated account discussed below.

Table 1. Human capital stock and investment, 2009	Market	Non-market	Total
Stock of human capital (tril.)	$231.6	$525.4	$757.0
Net investment in human capital (tril.)	$2.6	$4.8	$7.4
Investment from births (tril.)	$4.0	$6.9	$10.9
Depreciation from deaths (tril.)	$0.4	$2.4	$2.8
Investment from education, net of aging of enrolled (tril.)	$3.7	$3.3	$7.0
Depreciation from aging of non-enrolled (tril.)	$5.3	$4.5	$9.9
Residual net investment (tril.)	$0.7	$1.6	$2.3
Real growth in stock (ann. 1998-2009)	0.8%	1.0%	0.9%
Real growth in net investment (ann. 1998-2009)	-0.8%	-1.8%	-1.4%
Real growth in investment from births (ann. 1998-2009)	0.4%	0.4%	0.4%
Real growth in depreciation from deaths (ann. 1998-2009)	0.2%	0.6%	0.5%
Real growth in net education investment (ann. 1998-2009)	1.7%	1.4%	1.6%
Real growth in aging of non-enrolled (ann. 1998-2009)	0.3%	0.5%	0.4%

Individual Years of Education

There are two major areas in which the data set has changed. First, the estimates in Christian (2010) were based on the October school enrollment supplements to the CPS, in which educational attainment has been measured since 1992 using qualifications earned rather than individual years of education (e.g., "some college but no degree" rather than 13, 14, or 15 years of education; see Jaeger, 1997). To handle this, the accounts in

Christian (2010) drew from, among other sources, lagged enrollments to impute the distribution of the population by individual years of education. The updated account recovers individual years of education by merging data from the publicly available basic CPS files, which since 1998 have included additional education questions from which variables that measure individual years of education can be created (Jaeger, 2003). Because these variables are unavailable before 1998, the updated account only goes as far back as then. A human capital account for the United States that uses the Current Population Survey that includes the years 1992 (the first year of the switch from individual years of education to qualifications earned) through 1997 (the last year before the new education questions were added to the publicly available basic CPS) will still require imputation or adaptation to account for the absence of individual years of education.

One useful aspect of being able to measure individual years of education at the person level is that all of the variables used to measure human capital--wages, the employment rate, hours worked, school enrollment, etc.--can vary by the individual year of education organically within the sample. In contrast, the imputations used in Christian (2010) made assumptions that limited that variability. In particular, the wage rate for any age and sex only varied across five broad educational groups--no high school diploma, high school diploma, some college, college degree, and advanced degree. One concern noted in Christian (2010) was that this might have led to inflated values of gross investment in education. The reasoning was that each year of education completed took on an immense gross investment value because, for many students, *not* completing a year of education meant falling behind the typical age-education progression (finishing high school at age 18, college at age 22, etc.), which in turn substantially reduced the likelihood that one would finish a diploma or degree down the road. Since the imputations only put direct wage gains in the data set when one completes a diploma or degree, the gross investment value of each year of education would be inflated by not allowing for direct wage gains from the intermediate years of education in between. Indeed, gross investment in education measured in Christian (2010) was immense; the market component was $16.4 trillion in 2005. For this reason, Christian (2010) measured investment in education net of the aging of persons enrolled in school; since this measured the value of moving along the age-education progression rather than the value of not falling behind it, the results were of a more plausible magnitude. Interestingly, allowing wages to vary by individual year of education, as the new data set does by measuring individual year of education at the person level, does not seem to have alleviated the problem. In the new data set, gross investment in education remains very large, with a market component of $15.6 trillion in 2005. Given this magnitude, most of the discussion of education that follows will, like Christian (2010), focus on investment in education net of aging.

The Treatment of Taxes

Second, the estimates in Christian (2010) used the federal marginal tax rate variable in the CPS to compute the post-tax wage used to value nonmarket time. The updated estimates compute the post-tax wage using federal and state marginal tax rates from the Internet version (v9) of TAXSIM (Feenberg and Coutts, 1993, http://www.nber.org/taxsim/). The post-tax wage only affects measures of the non-market component of human capital; the market component of human capital is measured using pre-tax wages to reflect the marginal return to labor received both by the workers themselves and by the government.

Table 2 presents selected human capital results for the non-market sector for 2009 using the CPS federal marginal tax rate variable, the federal marginal tax rate computed from TAXSIM, and federal and state marginal tax rates computed from TAXSIM. In all three of these cases, marginal tax rates are computed at the individual level: a separate tax rate is computed for each person in the sample used to compute human capital. A fourth set of human capital results are presented for 2009 using an average federal and state marginal tax rate that applies to all persons in a given year (published at the TAXSIM web site at http://www.nber.org/~taxsim/marginal-tax-rates/at.html). The fourth approach, unlike the previous three, eliminates progressivity in marginal tax rates. Only the non-market component is presented because the market component is unaffected by the choice of tax rate.

Table 2. Nonmarket human capital, 2009	CPS	TAXSIM fed only	TAXSIM fed+state	Average fed+state
Stock of human capital	$557.1	$550.4	$525.4	$515.7
Net investment in human capital	$5.2	$5.1	$4.8	$5.1
Investment from births	$7.3	$7.2	$6.9	$6.8
Depreciation from deaths	$2.4	$2.5	$2.4	$2.2
Investment from education, net of aging	$3.7	$3.5	$3.3	$3.9
Depreciation from aging of non-enrolled	$5.0	$4.8	$4.5	$4.9
Residual net investment	$1.7	$1.6	$1.6	$1.5
Real growth in stock	1.0%	1.0%	1.0%	1.0%
Real growth in net investment	-1.9%	-1.8%	-1.8%	-1.6%
Real growth in investment from births	0.4%	0.4%	0.4%	0.4%
Real growth in depreciation from deaths	0.6%	0.6%	0.6%	0.7%
Real growth in net education investment	1.5%	1.5%	1.4%	1.6%
Real growth in aging of non-enrolled	0.4%	0.5%	0.5%	0.3%

The inclusion of state taxes has a modest negative effect on nominal measures of nonmarket human capital. When the TAXSIM model is used, including state taxes as well as federal taxes reduces the nonmarket stock of human capital by 5 percent, nonmarket net investment in human capital by 5 percent, and nonmarket net investment in education by 7 percent. The disproportionately large effect on investment in education is likely a result of state taxes adding to the progressivity of the tax structure in the data set; as taxes become more progressive, the post-tax wage return to education drops. In contrast, the inclusion of state taxes has only small effects on growth rates of real measures of nonmarket human capital.

Larger distortions take place when the progressivity of marginal taxes is ignored entirely and a single average marginal tax rate is applied to everyone. While the nominal human capital stock is for the most part unaffected, nominal measures of investment change more substantively. Total nonmarket net investment is 6 percent higher and, of particular interest, nonmarket net investment in education is 18 percent higher. Real growth rates in investment are also changed by the use of a flat marginal tax rate, with the rate of growth in total net investment higher by 0.2 percentage points and the rate of growth in net investment in education higher by (after rounding) 0.1 percentage points per year.

IV. Discount and Income Growth Rates

The Jorgenson-Fraumeni approach to measuring human capital requires specifying an income growth rate (for projecting future annual incomes from current annual incomes) and a discount rate (for aggregating current and future annual incomes into lifetime incomes in present discount value). The income growth rate of 2 percent and discount rate of 4 percent used in Christian (2010) and in the account presented here are the same as those used in Jorgenson and Fraumeni (1989). Income and growth rates used in the primary results in other studies are summarized in Table 3 below.

Table 3. Discount and income growth rates used in human capital accounts				
Study	Country	Income growth rate	Discount rate	Notes
Jorgenson and Fraumeni (1992)	United States	1.32	4.58	Income growth rate is estimate of Harrod-neutral productivity growth; discount rate is long-term rate of return in private sector
Ahlroth *et al* (1997)	Sweden	1.89	5.44	
Ervik *et al* (2003), Liu and Greaker (2009)	Norway	2.5	3.5	Discount rate is rate recommended for cost-benefit analysis by finance ministry
Wei (2004)	Australia	1.32	4.58	
Le *et al* (2006)	New Zealand	1.5	6	
Li *et al* (2010)	China	4.11 (rural); 6 (urban)	4.58	Income growth rate is growth in labor productivity
Jones and Chiripanhura (2010)	United Kingdom	2	3.5	
Gu and Wong (2010a)	Canada	1.7	5.1	Income growth rate is growth in labor productivity in business sector; discount rate is weighted average rates of return on equity and debt

Compared to the other studies presented in Table 3, a 2 percent income growth rate and a 4 percent discount rate seems more generous than tight-fisted. In Table 4, results for the market component of human capital that assume a 1 percent income growth rate and a 6 percent discount rate are presented for contrast; this particular parameterization was also used as a robustness check in Jorgenson and Fraumeni (1989). A wider gap between the income growth rate and the discount rate should lead to smaller measures for human capital, since the lower income growth rate reduces future incomes and the higher discount rate reduces the present valuation of future incomes.

Abraham (2010) notes that one of the reasons that substantial differences exist between income-based and cost-based measures of investment in education is because the discount rate used in human capital accounts is typically much lower than the rate of return on education. This may reflect the difference between the rate of return on education required to make the investment worthwhile from a social perspective and the rate required to make the investment worthwhile from an individual perspective; while the latter is quite high due to uncertainty about the return an individual will eventually receive, the former is much lower since the return is diversified across individuals. Consequently, while the discount rates used in the human capital accounts described above range from 3.5 percent to 6 percent, the rate of return to education has a range of between 7 percent and 12 percent (Oreopoulous and Salvanes, 2009). To examine the extent to which this contributes to the difference, the human capital account is re-estimated using an income growth rate of 1 percent and a discount rate of 12 percent.

Table 4. Market human capital stock and investment under alternative income growth rates and discount rates, 2009	IG:2% D:4%	IG:1% D:6%	IG:1% D:12%
Stock of human capital (tril.)	$231.6	$135.4	$69.6
Net investment in human capital (tril.)	$2.6	$1.5	$0.8
Investment from births (tril.)	$4.0	$1.2	$0.2
Depreciation from deaths (tril.)	$0.4	$0.3	$0.2
Investment from education, net of aging of enrolled (tril.)	$3.7	$2.9	$1.7
Depreciation from aging of non-enrolled (tril.)	$5.3	$2.7	$1.1
Residual net investment (tril.)	$0.7	$0.4	$0.2
Real growth in stock (ann. 1998-2009)	0.8%	0.9%	1.0%
Real growth in net investment (ann. 1998-2009)	-0.8%	-1.8%	-3.3%
Real growth in investment from births (ann. 1998-2009)	0.4%	0.4%	0.4%
Real growth in depreciation from deaths (ann. 1998-2009)	0.2%	0.4%	0.6%
Real growth in net education investment (ann. 1998-2009)	1.7%	1.6%	1.7%
Real growth in aging of non-enrolled (ann. 1998-2009)	0.3%	1.2%	3.1%

It should be unsurprising that the nominal measures of human capital investment fall substantially when the income growth rate is reduced and the discount rate is driven upward. One interesting result is that measured real growth in depreciation from aging of persons not enrolled in school becomes greater as the gap between the income growth rate and the discount rate rises. This, in turn, makes real growth in net human capital investment more negative. Why is this the case? Between 1998 and 2009, there was a substantial increase in the number of people between the ages of 52 and 63, henceforth referred to as late-career persons. The population of late-career persons grew by a total of 55 percent between 1998 and 2009, while the rest of the population grew by a total of only 6 percent. A rise in the number of late-career persons means that the overall effects of the aging of the population will increasingly reflect the specific effects of the aging of late-career persons. This will generally lead to more depreciation since, from a human capital perspective, the effects of aging are more severe among late-career persons. The aging of late-career persons is almost entirely depreciation; as late-career persons age, they leave years of earnings behind them. In contrast, the aging of younger persons has both depreciation and appreciation components. On one hand, younger persons leave earnings behind as they age, causing depreciation; at the same time, younger persons also get nearer and nearer as they age to the higher earnings they will receive later in their careers, leading to appreciation. The appreciation effect among younger persons becomes greater as the discount rate rises. Consequently, the higher the discount rate, the greater the degree to which depreciation from aging is more severe among late-career persons than it is among younger persons. As a result, when the discount rate is high, a shift in population toward late-career persons more substantially increases depreciation from aging, which in turn leads to the higher measured growth rates in depreciation from aging that we see in Table 4.

It is also interesting to note that even in the case where the income growth rate is set to 1 percent and the discount rate is set to 12 percent, the market component of net investment in education is equal to $1.7 trillion, which is still nearly twice the size of the $909 billion education sector measured in the cost-based National Income and Product Accounts.[1] Does this suggest that persons are receiving a substantial surplus from education? On the income side, while investment in the education sector net of aging is used in this account because it is easy to compute and because it relies on fewer counterfactual assumptions, a measure of gross investment in education that does not include the effects of aging while in school is what ultimately ought to drive personal decisions about education. This is because people will age regardless of whether they attend school or not; consequently, the decision to pursue education should be neutral to the effects of aging. Under traditional assumptions, gross investment in education is very large (even when the income growth rate is 1 percent and the discount rate is 12 percent, its market component is equal to $3.1 trillion), but this is primarily because the traditional model assumes that students who miss a year of education fall "off track" and face a much lower probability of completing diplomas and degrees down the road. In contrast, gross investment in education is more modest when one assumes that students who attended school would not have fallen "off track" had they missed a year of education, and instead would have enrolled in school a year later with the same probabilities as a year before. Under this counterfactual, explained in more detail in Christian (2010), the market component of gross investment in education is $1.18 trillion when the income

[1] Author's calculation from the National Income and Product Accounts, adding personal consumption expenditures on education services ($223 billion, from table 2.4.5) to government consumption expenditures on education ($686 billion, from table 3.17).

growth rate is 1 percent and the discount rate is 12 percent.[2] However, the government claims a substantial part of the return to this investment in taxes. After accounting for taxes by adjusting the wage rate with an average tax rate and re-estimating human capital, the market component of gross investment in education drops to $979 billion. Since the return to education is not enjoyed until a year later, this amount ought to be multiplied by 1.01 and divided by 1.12 to account for income growth and discounting; this further reduces the amount to $883 billion.

On the cost side, the cost to persons (as opposed to governments) of education includes both direct costs and foregone earnings. The direct costs of education to persons were $223 billion in 2009 while, using the data in the human capital account, the opportunity cost of time spent in school was $377 billion. Adding the direct cost and time cost together yields a total personal cost of $600 billion, which, even at a very high discount rate, is substantially less than the $883 billion personal return to education. Even at these very high discount rates, the personal return to education is about half again as much as the personal cost.

It is useful to note that the above computation includes both elementary and secondary education as well as higher education. Elementary and secondary education is an interesting case, especially from the cost side, since much of it is compulsory, free of direct cost, and attended by students who (at least in this account) are too young to have an opportunity cost of time. Higher education, by contrast, is more characteristic of an economic decision. Applying the above computations to higher education alone yields a personal return of $440 billion (computed from a $648 billion pretax gross investment,

[2] This is smaller than investment net of aging because, in this particular case, depreciation due to aging is negative, likely because of the cases of children and young adults, who come closer to their prime earning adult ages as they get older.

adjusted after taxes to $488 billion, multiplied by 1.01 and divided by 1.12). The time cost to persons of higher education was $217 billion and the direct cost was $146 billion, combining to a total cost of $363 billion.[3] Comparison of the return and cost estimates suggests that the personal return to higher education is a little more than 20 percent greater than the personal cost, which in turn suggests that individuals receive a substantial surplus from education, even when the parameterization is conservative.

V. Smoothing and Imputation

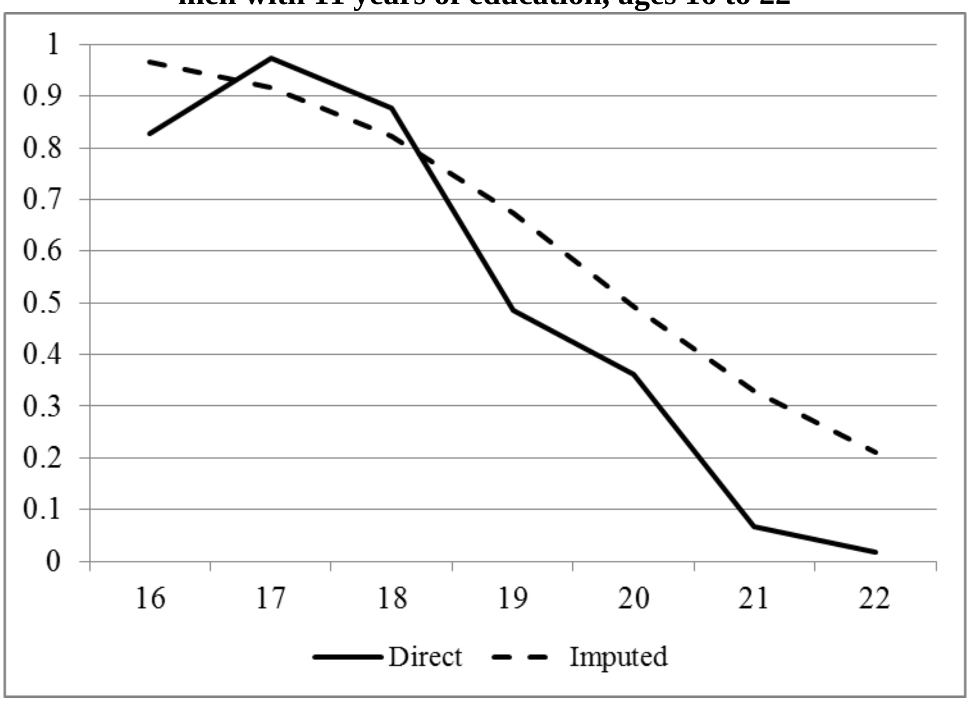
The human capital model for Sweden produced by Ahlroth *et al* (1997) was created from an annual survey of about 6,000. This sample is too small to estimate realistic means of wages, hours worked, school enrollment, and other variables for each age, sex, and education cell in the human capital data set; given there are 61 age groups, 2 sexes, and 18 levels of education in their model, there are up to 2,196 cells to fill. To fill these cells, the authors specified wages, probability of employment, hours spent at work conditional on employment, and probability of school enrollment as regression functions of sex, age, education, age squared, education squared, age times education, and age squared times education squared. The authors then estimated these regressions over their person-level sample (with log wages and hours spent at work as linear regressions and probabilities of employment and enrollment as logistic regressions) and used the estimated regression coefficients to impute values for these variables to each cell. These imputations make measuring human capital possible even with a small sample.

There are few problems from small samples in the United States, where the Current Population Survey regularly interviews more than 100,000 persons each month. However, an approach that imputes the variables used to build human capital using a

[3] Direct cost is measured from the National Income and Product Accounts, table 2.4.5.

regression equation with age and education on the right-hand side has some interesting qualities. In particular, it smooths wages, hours, earnings, and enrollment, reducing jumps and spikes over age and education. For example, Figure 1 presents two sets of school enrollment rates for men with 11 years of education between ages 16 to 22. The first uses rates computed directly from the Current Population Survey. The second uses rates imputed from a logistic regression of school enrollment on age, education, age squared, education squared, age times education, and age squared times education squared.

Figure 1. School enrollment rates, 2009,
men with 11 years of education, ages 16 to 22

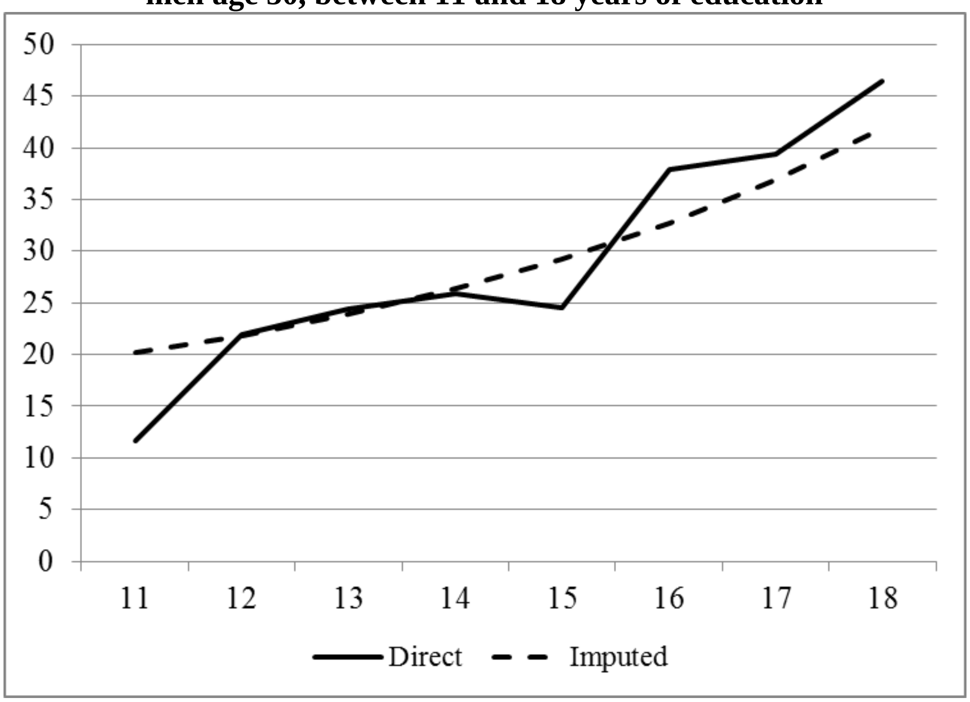


One substantive difference between the directly computed school enrollment rate and the imputed school enrollment rate is that the extent to which people are affected by falling off the typical age-education progression is reduced in the imputed case. Most Americans finish their twelfth year of education by the end of age 18, so persons who are

19 years old but who have only finished 11 years of education have fallen off track. In the directly computed case, a man with 11 years of education faces a serious drop in the probability of continuing further education upon reaching age 19, with school enrollment rates dropping from 88 percent to 49 percent. However, in the imputed case, the school enrollment rate drops from 82 percent to 67 percent. This is still a substantial drop, but from the perspective of years of education ultimately completed, the implication of missing a year of school is smaller.

A similar smoothing takes place in wages and earnings. Figure 2 plots the average pre-tax wage of men of 50 years of age and of between 11 and 18 years of education, in both the direct case and the imputed case.

Figure 2. Pre-tax wage rate, 2009,
men age 50, between 11 and 18 years of education



In the direct case, the relationship between wages and education is jumpy, with evident sheepskin effects at the twelfth (high school diploma) and sixteenth (bachelor's degree) year of education. In the imputed case, the wage rate rises smoothly as years of education rise. This may also reduce the implication of missing a year of school. If missing a year of school reduces the probability of finishing a diploma or a degree down the line, the imputed approach may reduce the cost of missing a year of school by reducing the importance of degree and diploma years and increasing the returns to the intermediate years of education in between.

If, in the imputed case, not attending a year of school has smaller implications for later educational attainment and, potentially, for earnings, then it may also be the case that measured gross investment in education under traditional assumptions is also small because the cost of not attending a year of schooling and falling "off track" from the typical age-schooling progression is smaller. Table 5 compares results from the baseline human capital model with results from a model in which many of the relevant variables are imputed for the market component of the human capital stock.[4]

Table 5. Market human capital stock and investment from baseline model and model with substantial imputations, 2009	Baseline	Imputed
Stock of human capital (tril.)	$231.6	$218.0
Net investment in human capital (tril.)	$2.6	$2.3
Investment from births (tril.)	$4.0	$3.7
Depreciation from deaths (tril.)	$0.4	$0.4
Investment from education, net of aging of enrolled (tril.)	$3.7	$3.9
Investment from education, gross, trad. assumptions (tril.)	$21.0	$16.8
Depreciation from aging of non-enrolled (tril.)	$5.3	$5.6
Residual net investment (tril.)	$0.7	$0.7
Real growth in stock (ann. 1998-2009)	0.8%	0.8%
Real growth in net investment (ann. 1998-2009)	-0.8%	-1.0%
Real growth in investment from births (ann. 1998-2009)	0.4%	0.4%
Real growth in depreciation from deaths (ann. 1998-2009)	0.2%	0.0%
Real growth in net education investment (ann. 1998-2009)	1.7%	1.4%
Real growth in aging of non-enrolled (ann. 1998-2009)	0.3%	0.5%

[4] These results will differ from the results in an earlier version of the paper (BEA Working Paper 2011-05) for having used the mean $\exp(X\beta + .5\sigma^2)$ rather than the median $\exp(X\beta)$ to impute wages from a log-linear regression $\log w = X\beta + \varepsilon$.

The imputations used in the alternative model are similar but not identical to those in Ahlroth *et al* (1997). The right-hand-side variables in each regression were age, education, age squared, education squared, age times education, and age squared times education squared. However, rather than include sex among the right-hand-side variables, separate regressions were estimated by sex instead. For each sex and each year, three different school enrollment regressions for three different left-hand-side variables were run using logistic regression: full-time enrollment in grades one through twelve; full-time enrollment in postsecondary education; and part-time enrollment in postsecondary education. Logistic regression was also employed for a model with the probability of employment as the left-hand-side variable. Finally, hours worked conditional on employment, log pre-tax wage rate, and log post-tax wage rate were imputed using ordinary least squares regression.

The imputations do have an effect on the market component of gross investment in education as measured under traditional assumptions; by using the imputation, the measured amount drops by a fifth, from $21.0 trillion to $16.8 trillion. However, this is still an enormous quantity that rivals the entire gross domestic product of the United States, a result that is in substantive contrast to Ahlroth *et al* (1997), whose income-based measure of gross investment in education in Sweden was actually lower than the cost-based measure used in the Swedish national accounts. The rest of the results are for the most part unaffected by the use of imputation, which bodes well for human capital accounting in cases where sample sizes are small.

VI. Valuation of Nonmarket Time

The human capital accounts presented both here and in Jorgenson and Fraumeni (1989, 1992) include both a market and non-market component. The non-market component is measured under the assumption that time spent outside of work, school (assumed to be 1300 hours a week for full-time enrolled students), and personal maintenance (assumed to be 10 hours a day) is spent in non-market activities that are valued at the post-tax marginal wage. Some of these activities are undeniably work that leads to production of goods and services in the home, such as cooking, laundry, home repairs, and child care. Other activities, such as watching television, make a weaker case for being classified as non-market production; one can make such a case (the only way to draw any utility from a television, for example, is to actually spend time watching it), but the case is weaker.

It is possible, with time-use survey data, to put restrictions on which activities are valued in the non-market component of a human capital account and which activities are not valued. Using the American Time Use Survey, the time of individuals is split into categories that reflect the degree to which it ought to be considered home production. Time is split into six different kinds of activities: market work, school, non-market production, child and adult care, leisure, and maintenance. Non-market production includes housework, cooking, cleaning, laundry, home repairs and maintenance, home management, shopping, using services (going to the post office, for example), and religious and civic activities. Child and adult care includes not just basic child care (feeding, grooming, etc.), but also educational (helping with homework, etc.) and recreational (playing sports, etc.) child care as well. Leisure includes reading, sports, hobbies, entertainment, socializing, and watching television. Finally, maintenance includes not only sleeping, eating, and personal care, but also commuting to work. Commuting is included in maintenance because commuting only exists to support work, so the value of time spent commuting to work is already accounted for in earnings from market work. These categories borrow heavily from Aguiar and Hurst's (2007) classification of time into non-market work and leisure. They also correspond reasonably well with Abraham and Mackie's (2005) recommendations for identifying household production for a satellite account.

The American Time Use Survey is a smaller sample; it surveys about 13,000 individuals each year between 2003 and 2009. To incorporate the smaller sample into the human capital estimates, imputations based on regressions similar to those used in Ahlroth *et al* (1997) are used. The proportion of total time spent in non-market production, child and adult care, leisure, and maintenance were each regressed on: a) age, education, age squared, education squared, age times education, and age squared times education squared; b) the proportion of time spent in market work and the proportion of time spent in school; and c) the variables in (a) interacted with the variables in (b). These regressions were estimated separately by sex and year and used to predict time spent in non-market production, child and adult care, leisure, and maintenance under three different approaches. In the first approach, maintenance is still assumed to be 10 hours per day and full-time school enrollment is still assumed to be 1300 hours per year. The remaining time outside of market work is divided among non-market production, child and adult care, and leisure in proportion to their predicted time from the above regressions. Only time spent in non-market work is valued in the human capital account.

The second approach is the same as the first approach, except that both non-market work and child and adult care are valued. In the third approach, maintenance time is increased to 11.08 hours per day, and school time among those enrolled in school full-time is increased to 1647 hours per year for elementary and secondary students and reduced to 1105 hours per year for postsecondary students. This is in accordance with the average time spent on maintenance and schooling measured from the American Time Use Survey. Like the second approach, both non-market work and child and adult care are valued in the third approach. The results from the three approaches are presented in Table 6.

Table 6. Nonmarket human capital stock and investment under alternative accounting for nonmarket time, 2009	Base model	Non-market work only	Non-market w/child care	Maint., school from ATUS
Stock of human capital (tril.)	$525.4	$174.6	$210.6	$189.0
Net investment in human capital (tril.)	$4.8	$1.8	$2.1	$1.9
Investment from births (tril.)	$6.9	$2.3	$2.9	$2.6
Depreciation from deaths (tril.)	$2.4	$0.7	$0.8	$0.7
Investment from education, net of aging (tril.)	$3.3	$1.4	$1.8	$1.6
Depreciation from aging of non-enrolled (tril.)	$4.5	$1.7	$2.5	$2.2
Residual net investment (tril.)	$1.6	$0.5	$0.6	$0.6
Real growth in stock (ann., 2003-2009)	0.9%	0.9%	0.9%	0.9%
Real growth in net investment (ann.)	2.7%	3.9%	4.5%	4.4%
Real growth in investment from births (ann.)	0.2%	0.2%	0.2%	0.2%
Real growth in depreciation from deaths (ann.)	0.1%	0.2%	0.2%	0.2%
Real growth in net education investment (ann.)	1.3%	1.4%	1.4%	1.4%
Real growth in aging of non-enrolled (ann.)	0.3%	0.3%	0.2%	0.2%

Opting to only value time spent in specifically defined nonmarket work has a very large negative effect on measures of the nonmarket component of the human capital stock, reducing it to one-third its value when all non-market, non-school time outside of maintenance is included. Net investment is reduced in rough proportion, with the largest proportional drop in depreciation due to deaths and the smallest in net investment from education. This would be the case if older people spent relatively less time in nonmarket work and if people increase the amount of non-market time spent in non-market work as their levels of education rise. Real growth rates in the human capital stock are unchanged when only time spent in nonmarket work activities is valued, but real net investment in human capital grows considerably faster in the alternative accounting. Interestingly, this growth in real net investment does not come from the measured causes of investment (births, deaths, aging, or education), but rather from the residual component of net investment--the changes in population that are left over once calculations for births, deaths, aging, and education have been made. This residual includes migration and measurement error, and faster growth in residual net investment in the alternative accounting implies that growth in this residual was in groups that spent relatively more of their non-market time in household work.

When child and adult care is added to the non-market component of human capital, the most substantive effect for nominal human capital investment is on aging of persons not enrolled in school. This is a result of people spending less time on child and adult care as they become older. Real growth in net investment becomes faster, and this is again primarily in the residual component of net investment. Changing the number of hours spent in school conditional on enrollment and on maintenance reduces the components of the human capital stock and investment in rough proportion to each other and has very little effect on real growth in stock and investment.

The above analysis is merely a start at exploiting the possibilities for alternative measurements of non-market time in human capital. For example, this account and the account of Jorgenson and Fraumeni (1989, 1992) value time spent in non-market activities at the tax-adjusted marginal wage of the person performing the activity. This approach to valuating non-market tasks will value tasks more highly when they are performed by more educated persons, even in cases where the performance of the task is not likely to improve with education; this point is made in Rothschild (1989) and elsewhere. Consequently, valuing non-market tasks at market wage will yield a substantive non-market component of investment from education. Alternatives to valuating non-market tasks at market wages include valuing them at a replacement wage equal to the cost of hiring someone in the market to perform the task for you, possibly adjusted for differences in productivity between the amateurs working in the home and the professionals working in the market; this is the approach recommended for a satellite account for household production in Abraham and Mackie (2005). Abraham (2010) considers an approach that differentiates the relationship between education and productivity between different non-market activities.

VII. Real Output of the Education Sector

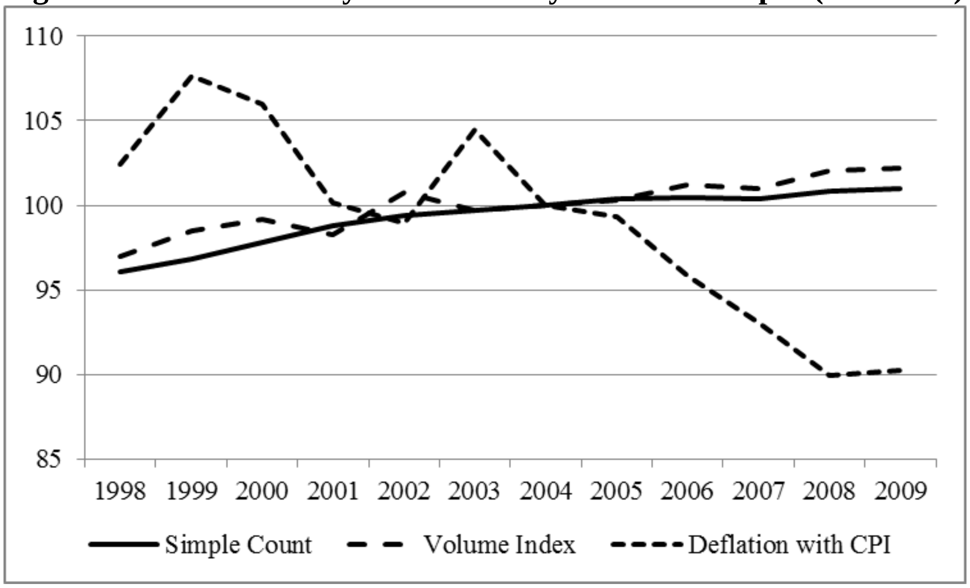
One of the most frequently cited applications of a human capital account is the use of investment in education as a measure of the output of the education sector. This is the motivation for one of the original Jorgenson and Fraumeni (1992) papers, is recommended for a satellite account in the Atkinson (2005) report, and was discussed among possible approaches for the United States in Christian and Fraumeni (2005).

In an income-based human capital account, investment in education is equal to the sum of persons who are enrolled in school across sexes, ages, and levels of education weighted by the lifetime return in present discounted value to a year of education by sex, age, and level of education. If investment in education is measured in real terms using enrollments as quantities and lifetime returns as weights, then real investment in education is a volume-based measure of the real output of the education sector. A volume-based measure of the real output of the education sector measures real output using a measure of the amount of education services produced, which is typically identified as enrollments; examples of volume-based measures for the United States are presented in Fraumeni *et al* (2009) and in Christian (2006). On the other hand, if investment in education is measured in real terms by deflating a nominal measure of net investment in education using a price index such as the Consumer Price Index, then investment in education is an outcome-based measure of the real output of the education sector. The measure is outcome-based since it would not measure the amount of services produced, but rather the outcome of those services, namely the value of the amount of extra production and consumption of goods and services made possible by the education.

Figure 3 below presents comparisons between three measures of the real output of the elementary and secondary education sector between 1998 and 2009. The first is a simple count of students enrolled in school--a straightforward volume index with no adjustments for changes in the quality of education over time. The second is growth in real investment in education net of aging of persons enrolled in school, using the baseline human capital account and treating enrollments as quantities and lifetime returns as weights. This approach, like the simple count of students, also does not account for changes in the quality of education over time but, unlike the simple count of students, weights enrollments of students by sex, age, and level of education using their net investment values. The third measure is real investment in education net of aging of persons enrolled in school, also using the baseline human capital account but computed by deflating nominal investment in education net of aging using the Consumer Price

Index. This is a measure of the real purchasing power of the return to education and is an outcome-based rather than a volume-based approach. Both the market and non-market components of net investment in education are included.

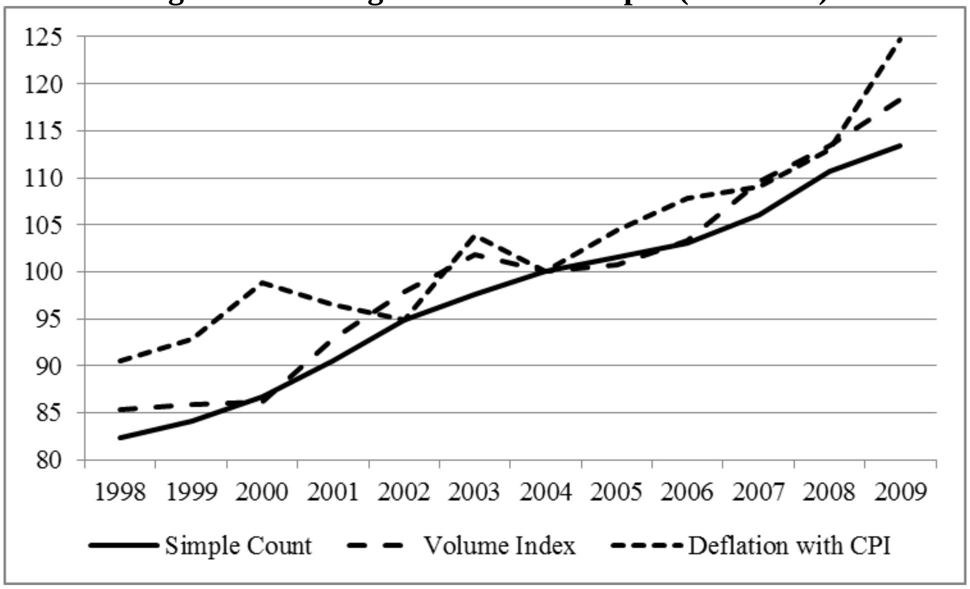
Figure 3. Real elementary and secondary education output (2004=100)



We can see in Figure 3 that the simple count and the volume index follow each other relatively closely. Both grew at an annual rate of 0.5 percent between 1998 and 2009, although the volume index grew more slowly in the 1998-2004 period (0.5 percent compared to 0.7 percent) and more quickly in the 2004-2009 period (0.4 percent compared to 0.2 percent). In contrast, nominal net investment deflated with the CPI presents a substantively different story, having declined at an annual rate of 1.1 percent between 1998 and 2009. This would be consistent with a decline in the lifetime return to elementary and secondary education in real terms over the period studied.

Figure 4 repeats this analysis for higher education, with the exception that the simple count of enrollments is measured in full-time equivalents rather than as an unadjusted headcount.

Figure 4. Real higher education output (2004=100)



All three series exhibit the same annual growth rate of 3.0 percent between 1998 and 2009, although there are wrinkles in growth between them in the intermediate years. In the 1998-2004 period, the simple count grows the fastest (3.3 percent), the volume index the second-fastest (2.7 percent), and the CPI-deflated index the slowest (1.7 percent), indicating a shift in higher education enrollments toward persons with lower levels of return to education and also a general decline in the return to education by sex, age, and level of education. Both trends reverse completely in the 2004-2009 period, so that the simple count (2.5 percent) grows more slowly than the volume index (3.4 percent), which in turn grows more slowly than the CPI-deflated index (4.5 percent).

These results are consistent with those of Gu and Wong (2010b), who conduct a similar analysis comparing the growth in real output of the education sector between a cost-based approach and an income-based approach, with both approaches producing volume indexes based on the number of students enrolled. In their estimates for Canada, a simple count of students grew at a rate of 0.6 percent per year, a cost-based volume index grew at a rate of 0.9 percent per year, and an income-based volume index grew at a rate of 0.7 percent per year between 1996 and 2005.

VIII. Conclusions and Suggestions for Further Research

The findings above suggest that an income-based approach to measuring human capital in the United States similar to that of Jorgenson and Fraumeni (1989, 1992) yields a very large estimate of the stock of human capital. In 2009, using an income-based approach that assumes a 2 percent income growth rate and a 4 percent discount rate, the stock of human capital in the United States was about three-quarters of a quadrillion dollars, of which about one-third was market and two-thirds was non-market. The market component of net investment in education was $3.7 trillion, which is nearly four times as great than the $909 billion education sector measured in the National Income and Product Accounts. When the analysis focuses strictly on costs and returns to individual persons and the discount rate is increased to 12 percent to reflect the riskiness of education as an investment, there appears to be substantial consumer surplus from education.

Real growth in net investment from education, which was 1.6 percent per year between 1998 and 2009 is, for the most part, robust to changes in the income growth rate, the discount rate, the treatment of taxes, the approach to smoothing and imputation, and the valuation of non-market time. Other aspects of human capital are less robust. While it should not be surprising that changing the income growth rate, the discount rate, the treatment of taxes, or the activities classified as nonmarket production changes the levels of the human capital stock or human capital investment substantially, there are also some cases where real growth in investment in human capital is changed as well. For example, reducing the income growth rate and increasing the discount rate substantially reduces the growth rate in net investment, primarily by increasing the magnitude of depreciation from aging among persons aged in their fifties and early sixties.

In general, the human capital account as a whole was robust to using regressions to impute employment, school enrollment rates, and wages by age, sex, and education. This bodes well for measuring human capital from small data sets from which reliable sample means cannot be measured by age, sex, and individual year of education.

The work above lends itself to many extensions. Perhaps the most immediately interesting extension would be to extend the series further back in time. Haveman *et al* (2003) presents results for a potential-income-based model that go back to 1975, and readily available data from the Current Population Survey can be used to extend a human capital account for the United States as far back as 1968. This could be used to identify effects on human capital of long-run phenomena such as rising educational attainment and increased participation of women in market work. Extending the time series backward would also allow for empirical analysis of the differences between the lifetime-income-based approach of Jorgenson and Fraumeni (1989, 1992) and the potential-income-based approach of Haveman *et al* (2003).

It would also be useful to see if results generated from other data sets within the United States would generate results similar to those generated in the Current Population Survey. This might be especially useful for the purposes of measuring human capital from a small data set that requires regressions or similar approaches to impute wages, employment and school enrollment by age, sex, and individual year of education. While measured human capital was for the most part robust to using regressions rather than sample means in the analysis of Section V, it is useful to note that this was the case when using regression coefficients from a large data set, the Current Population Survey, which, being large, will produce precisely measured regression coefficients. It would be useful to see if a human capital account generated entirely from a smaller data set, such as the Panel Study of Income Dynamics, would generate comparable results.

The alternative measures of the non-market component of human capital in Section VI is only a start to the application of time-use data to human capital accounts. The approach used was a model that uses regression techniques to impute the distribution of time using age, sex, education, and the extent of time spent in the market and in schooling. The robustness of these results to alternative assumptions about the function that determines the distribution of time across different activities is relatively low-hanging fruit. In addition, using alternative assumptions about the meaning of non-market work could yield further informative results. For example, in the results in Section VI, the classification of activities as non-market work is a bright-line rule--either an activity is production or it is not. An alternative approach would allow that some activities are partially production and partially consumption. For example, Christian's (2007) account for household production of health care counted 20 percent of time spent in sports and exercise toward health-related production and the remaining 80 percent toward consumption. A third aspect of non-market production that suggests further investigation is the effect on the accounts from valuing of time spent in nonmarket activities at the wage of the person performing the activities rather than at the market cost of hiring another person to do it.

Abraham (2010) discusses a substantial number of important issues in human capital measurement, most of which focused on measuring the output of the education sector. The discussion sets out a plan for an satellite education account that includes both cost-based and income-based approaches to measuring human capital, mirroring the expenditure and income sides in the double-entry bookkeeping structure of a national account. Costs and income could include both market and non-market components, the latter of which would likely require further use of time-use data. Jorgenson (2010) elaborates on the relevant issues of a satellite account. Abraham (2010) also discusses fundamental questions about the attribution of income differences across different education levels to formal education itself. For example, persons who attain higher levels of education may have received more inputs not just from schooling but also from their families, and may also receive more on-the-job training. Income growth from technological change, even when skills-neutral, will also amplify differences in lifetime earnings between different education levels, even through the technology is completely divorced from the education sector.

The usefulness of human capital ultimately comes down to its potential for practical application. This point is made by McGrattan (2010), who finds a disconnect between human capital accounting and applied economics research and recommends that research in human capital focus less on the size of the human capital stock and more on economic questions. The results on the real output of the education sector in Section VII are in part an attempt to connect human capital to an economic application, in this case to a related issue in the economics of education. Gu and Wong (2010b) conduct a similar analysis for the output of the education sector in Canada, comparing real growth in education output between cost-based and income-based approaches. Recently produced accounts in several countries discuss macroeconomic applications, with a particular focus on economic growth, sustainable development, and productivity (Kokkinen, 2008; Le *et al*, 2006; Gu and Wong, 2010a; Jones and Chiripanhura, 2010; Li *et al*, 2010; Liu and Greaker, 2009). The OECD project should facilitate international comparison (Mira and Liu, 2010). Wei (2008) mentions that the human capital framework can be particularly useful for studies of education, migration, and aging. Haveman *et al* (2003) makes use of disaggregations of a potential-income-based measure of human capital to analyze potential earnings and capacity utilization by race, age group, and education level. Jorgenson (2010) identifies human capital as one of the most important additions to accounting for non-market activities in national accounts. As human capital estimates become internationally more widespread and the number of researchers to whom they become available increases, the number of applications of human capital should increase with the collective creativity of its users.

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Appendix: Human Capital, 1998-2009

Table A1. Human Capital, Market and Non-Market Combined, Nominal ($Tril.)

		Net Human Capital Investment						
Year	Stock	Total	Births	Deaths	Education	Aging	Residual	Revaluation
1998	478.7	6.3	6.6	1.9	4.9	6.7	3.4	15.3
1999	500.3	4.9	6.7	2.1	5.3	7.0	2.1	13.2
2000	518.4	6.3	7.2	1.9	5.5	7.9	3.3	18.0
2001	542.6	4.7	7.5	2.1	5.4	7.8	1.7	13.8
2002	565.1	5.1	7.9	2.2	5.4	7.8	1.8	22.8
2003	593.0	4.8	8.5	2.2	6.0	8.6	1.1	22.2
2004	620.0	5.3	8.8	2.4	5.9	8.3	1.3	19.1
2005	644.4	5.5	9.1	2.5	6.2	8.6	1.4	22.9
2006	672.8	7.3	9.9	2.5	6.3	9.0	2.6	27.1
2007	707.2	5.1	10.4	2.8	6.4	9.1	0.1	10.9
2008	723.1	5.2	10.6	2.7	6.7	9.6	0.2	28.7
2009	757.0	7.4	10.9	2.8	7.0	9.9	2.3	

Table A2. Human Capital, Market and Non-Market Combined, Real (2009 $Tril.)

		Net Human Capital Investment				
Year	Stock	Total	Births	Deaths	Education	Aging
1998	683.4	8.7	10.4	2.6	5.9	9.5
1999	692.3	6.7	10.4	2.7	5.9	9.8
2000	699.1	8.3	10.7	2.7	6.0	9.9
2001	707.4	6.1	10.6	2.7	6.1	9.9
2002	713.5	6.5	10.5	2.7	6.4	9.7
2003	720.0	5.8	10.8	2.8	6.4	9.8
2004	725.8	6.1	10.8	2.7	6.4	9.7
2005	732.2	6.0	10.9	2.8	6.4	9.8
2006	738.3	7.8	11.2	2.8	6.5	9.8
2007	746.3	5.3	11.4	2.8	6.7	10.0
2008	751.6	5.4	11.2	2.8	6.8	9.9
2009	757.0	7.4	10.9	2.8	7.0	9.9

Note: Net human capital investment from education is investment net of depreciation from aging of enrolled persons, while net human capital investment from aging is depreciation from aging of non-enrolled persons. Deaths and aging are depreciation rather than investment.

Table A3. Human Capital, Market Only, Nominal ($Tril.)

		Net Human Capital Investment						
Year	Stock	Total	Births	Deaths	Education	Aging	Residual	Revaluation
1998	153.2	1.9	2.4	0.3	2.6	3.9	1.1	3.5
1999	158.6	1.3	2.4	0.3	2.8	4.1	0.6	12.1
2000	172.0	2.0	2.7	0.3	2.9	4.5	1.2	-2.8
2001	171.2	1.2	2.7	0.3	2.8	4.3	0.4	3.8
2002	177.9	1.3	2.8	0.3	2.8	4.3	0.3	4.9
2003	184.2	1.3	3.0	0.3	3.0	4.5	0.2	3.4
2004	188.9	1.4	3.1	0.3	2.9	4.5	0.2	7.4
2005	197.7	1.4	3.2	0.4	3.0	4.7	0.2	9.9
2006	208.9	2.0	3.6	0.4	3.1	4.9	0.6	6.6
2007	217.5	1.2	3.8	0.4	3.2	5.0	-0.4	4.9
2008	223.6	1.3	3.9	0.4	3.4	5.1	-0.4	6.8
2009	231.6	2.6	4.0	0.4	3.7	5.3	0.7	

Table A4. Human Capital, Market Only, Real (2009 $Tril.)

		Net Human Capital Investment				
Year	Stock	Total	Births	Deaths	Education	Aging
1998	212.1	2.8	3.8	0.4	3.1	5.1
1999	214.7	1.8	3.8	0.4	3.1	5.4
2000	216.5	2.7	3.9	0.4	3.1	5.4
2001	218.9	1.7	3.9	0.4	3.2	5.4
2002	220.5	1.8	3.8	0.4	3.3	5.3
2003	222.1	1.7	4.0	0.4	3.4	5.3
2004	223.7	1.8	4.0	0.4	3.3	5.3
2005	225.3	1.7	4.0	0.4	3.4	5.3
2006	226.9	2.4	4.1	0.4	3.4	5.3
2007	229.1	1.3	4.2	0.4	3.5	5.4
2008	230.3	1.4	4.1	0.4	3.6	5.4
2009	231.6	2.6	4.0	0.4	3.7	5.3

Note: Net human capital investment from education is investment net of depreciation from aging of enrolled persons, while net human capital investment from aging is depreciation from aging of non-enrolled persons. Deaths and aging are depreciation rather than investment.

Table A5. Human Capital, Non-Market Only, Nominal ($Tril.)

Year	Stock	Net Human Capital Investment						Revaluation
		Total	Births	Deaths	Education	Aging	Residual	
1998	325.5	4.4	4.2	1.6	2.3	2.8	2.3	11.8
1999	341.6	3.6	4.3	1.8	2.5	2.9	1.6	1.2
2000	346.4	4.3	4.6	1.6	2.6	3.5	2.1	20.8
2001	371.5	3.5	4.8	1.8	2.6	3.5	1.3	10.0
2002	387.1	3.8	5.1	1.9	2.6	3.5	1.5	17.9
2003	408.9	3.5	5.5	1.8	3.0	4.1	1.0	18.8
2004	431.1	3.9	5.7	2.0	3.0	3.8	1.1	11.7
2005	446.7	4.1	5.9	2.1	3.2	4.0	1.2	13.0
2006	463.9	5.3	6.3	2.1	3.2	4.1	2.0	20.5
2007	489.7	3.9	6.6	2.3	3.2	4.1	0.5	6.0
2008	499.6	3.9	6.7	2.3	3.3	4.5	0.6	21.9
2009	525.4	4.8	6.9	2.4	3.3	4.5	1.6	

Table A6. Human Capital, Non-Market Only, Real (2009 $Tril.)

Year	Stock	Net Human Capital Investment				
		Total	Births	Deaths	Education	Aging
1998	471.3	5.9	6.6	2.2	2.8	4.3
1999	477.5	4.9	6.6	2.3	2.8	4.5
2000	482.6	5.6	6.8	2.3	2.9	4.5
2001	488.4	4.4	6.7	2.3	2.9	4.5
2002	493.0	4.8	6.7	2.3	3.0	4.4
2003	497.9	4.1	6.8	2.4	3.1	4.5
2004	502.2	4.3	6.9	2.3	3.0	4.4
2005	506.8	4.4	6.9	2.4	3.0	4.5
2006	511.4	5.5	7.1	2.3	3.1	4.5
2007	517.2	4.0	7.2	2.4	3.2	4.6
2008	521.3	4.1	7.1	2.4	3.2	4.5
2009	525.4	4.8	6.9	2.4	3.3	4.5

Note: Net human capital investment from education is investment net of depreciation from aging of enrolled persons, while net human capital investment from aging is depreciation from aging of non-enrolled persons. Deaths and aging are depreciation rather than investment.