Human Capital Accounting in the United States, 1994–2006

By Michael S. Christian

THIS paper presents a human capital account for the United States from 1994 to 2006. Its methods are borrowed heavily from Jorgenson and Fraumeni (1989, 1992), although it deviates in some aspects. Like previous human capital accounts, it finds that the stock of human capital is very large—nearly three-quarters of a quadrillion dollars in 2006 if both its market and nonmarket components are included. The account breaks down human capital investment among the effects of births, deaths, aging, and education on human capital. Measures of gross investment in education are found to be very sensitive to counterfactual assumptions; consequently, investment in education is measured net of aging.

The account departs from Jorgenson-Fraumeni by measuring investment in education net of aging of enrolled persons rather than gross investment in education. A discussion of gross investment in education and its sensitivity to different assumptions concludes the paper.

Creating an Analysis Data Set for Human Capital Accounting

The central data set used in producing the human capital account is the October school enrollment and March demographic supplements to the Current Population Survey (CPS). From these data, nearly all of the information needed to produce an analysis data set suitable for producing a human capital account is available.

Population and school enrollment

The October CPS is used to measure the population and school enrollment components of the analysis data set. This part of the analysis data set includes population and school enrollment rates by age, sex, and individual year of education for persons ages 0 to 34 for each year between 1994 and 2006. It also includes population by age, sex, and membership in one of five broad education categories (no high school diploma, high school diploma, some college, bachelor's degree, and advanced degree) for persons ages 35 and older. The greater detail in the data set for persons ages 0 to 34 is a result of this group being of school-going age; it is necessary to measure their educational attainment by the individual year to account for their investment in education from school enrollment. It is presumed that persons age 35 and older are past school-going age; age is top coded at 80.

A change in the CPS in 1992 makes the measurement of educational progress by individual year of education particularly challenging. Starting in 1992, the CPS switched to a set of education categories that focused more on degrees and certifications earned, such as "high school graduate," "some college but no degree," and "bachelor's degree." An informative discussion of this switch is in Jaeger (1997). To accommodate this switch, the distribution of persons by individual years of education is imputed using data from the October CPS. The October CPS school enrollment supplement includes variables about whether persons were enrolled in school and in which individual grade or year of school the person was enrolled. These variables make it possible to plausibly guess the number of years of education completed by persons who are enrolled in school: one can realistically assume that a person who is enrolled in a particular year of school has completed education up to the year before. The school enrollment variables are also useful in guessing the distribution of the individual years of education of persons who are not enrolled in school. In some cases, it is realistic to assume that the distribution of individual years of education of persons who are not enrolled in school is the same as that of persons who are enrolled in school, conditional on age, sex, and broadly measured educational attainment. In other cases, historical data on enrollments going backward into the past for a particular cohort can be used to guess the distribution of individual years of education of persons in that cohort at a given time.

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Earnings, wages, hours of work, and nonmarket hours

The March CPS is used to measure the labor and earnings components of the data set. Average earnings, average hours of work, and the average post-tax wage are measured by age, sex, and broad education category (no high school, high school, some college, bachelor's degree, advanced degree) for the years 1994 to 2006. One implication of measuring average earnings, hours of work, and wages within five broad education categories is that in this human capital account, there are large direct payoffs to finishing degrees and diplomas and no direct payoffs to finishing the intermediate nondegree years of education in between. However, investment in education still has value even in nondegree years since each year of schooling moves a person 1 year closer to a degree, increasing the probability of earning the degree's payoff.

Measuring births, deaths, education, and aging

At this point, the analysis data set contains the following variables, each within year, age, sex, and education, and (with the exception of death rates) drawn entirely from the CPS.

pcount	Population
senr	School enrollment rate
ymi	Average yearly earnings per person
mhrs	Average yearly work hours per person
shrs	Average yearly hours in school per person. $1300 \times senr$
nmhrs	Average yearly nonmarket hours per person. $5110 - shrs - mhrs$
ynmi	Average value of yearly nonmarket hours per person. Equals *nmhrs* times the post-tax wage rate
sr	Survival rate, from the life tables of the Centers for Disease Control. Only differentiated by year, age, and sex

From these data, changes in population can be broken down among births, deaths, aging, education, and a residual term that covers migration and measurement error. To account for changes in the CPS' approach to weighting observations from year to year, the CPS-based data were adjusted to conform to national aggregates from alternative sources: population from the Census Bureau; enrollment from the Common Core of Data, the Private School Universe Survey, and the Integrated Postsecondary Education Data System, and births and deaths from the National Center for Health Statistics.[1]

Measuring Human Capital and Human Capital Investment

With the analysis data set assembled, the work of producing a human capital account begins. The steps involved in producing a human capital account are borrowed heavily from the accounts of Jorgenson and Fraumeni (1989, 1992).

Per capita human capital

The human capital stock is equal to the lifetime labor incomes—market and nonmarket—of the entire U.S. population. The first step in measuring this stock is measuring average lifetime labor income by year, age, sex, and education, which could also be understood as a measure of per capita human capital. Per capita human capital by year, sex, age, and education is measured starting with the oldest age group and moving backward. Per capita market human capital for the oldest age group in the data set—the age 80 and older group—is measured as follows:

$$mi_{y,s,80+,e} = [1-(1+\rho)^{-1} sr_{y,s,81+,e}(1+g)]^{-1} ymi_{y,s,80+,e}$$

where $mi_{y,s,80+,e}$ is per capita market human capital in year y of persons age 80 and older of sex s and education e, ρ is the yearly discount rate, $sr_{y,s,81+,e}$ is the survival rate in year y of persons of sex s who are age 80 or older, and g is the yearly rate of income growth.[2] Per capita market human capital is equal to the present discounted value of expected lifetime market labor income of a person of age 80 or over, conditional on constant discount, income growth, and survival rates. Its nonmarket equivalent—which is based not on earnings but on the value of nonmarket time—is measured as

$$nmi_{y,s,80+,e} = [1-(1+\rho)^{-1} sr_{y,s,81+,e}(1+g)]^{-1} ynmi_{y,s,80+,e}$$

where $nmi_{y,s,80+,e}$ is per capita nonmarket human capital in year y of persons age 80 and older of sex s and education e.

From the oldest age group, one can work backwards to measure the human capital of persons 1 year younger. Between the ages of 35 and 79, it is presumed that persons do not enroll in school; consequently,

1. For a discussion of changes in weighting in the CPS, see the "Historical Comparability" section of the Bureau of Labor Statistics CPS documentation at www.bls.gov/cps/eetech_methods.pdf.

2. This approach to handling persons age 80 and over is different from that of Jorgenson and Fraumeni, which sets the human capital of persons above a particular age threshold at zero.

there is no need to account for persons moving up to higher levels of education. Per capita human capital in these age groups is measured rather simply as:

$$mi_{y,s,a,e} = ymi_{y,s,a,e} + (1+\rho)^{-1} sr_{y,s,a+1}(1+g)\, mi_{y,s,a+1,e}$$

$$nmi_{y,s,a,e} = ynmi_{y,s,a,e} + (1+\rho)^{-1} sr_{y,s,a+1}(1+g)\, nmi_{y,s,a+1,e}$$

At these ages, per capita human capital is equal to earnings in the current year plus an expectation of per capita human capital in the following year, taking into account aging and rates of survival, time preference, and income growth.

Between the ages of 5 and 34, it is possible to enroll in school and move up to a higher level of education. Per capita human capital in these age groups is measured as

$$mi_{y,s,a,e} = ymi_{y,s,a,e} + [(1+\rho)^{-1} sr_{y,s,a+1}(1+g)]$$
$$[senr_{y,s,a,e}\, mi_{y,s,a+1,e+1} + (1-senr_{y,s,a,e})mi_{y,s,a+1,e}]$$

$$nmi_{y,s,a,e} = ynmi_{y,s,a,e} + [(1+\rho)^{-1} sr_{y,s,a+1}(1+g)]$$
$$[senr_{y,s,a,e}\, nmi_{y,s,a+1,e+1} + (1-senr_{y,s,a,e})nmi_{y,s,a+1,e}]$$

This is the same as that for the older age groups except that now expectations of per capita human capital in the following year includes the likelihood of school enrollment as well as aging, survival, time preference, and income growth. For ages below 15, earnings is set to zero as is the value of nonmarket time, so all human capital derives from expectations of future earnings and values of nonmarket time.

Finally, between the ages of 0 and 4, it is not possible to enroll in school. For this group, per capita human capital is set the same way as it is for those between the ages of 35 and 79 except that earnings and value of nonmarket time are set to zero. Education is also set to the lowest education group of no education.

The human capital stock and net human investment

The human capital stock is measured by taking the weighted sum of the population within years across sex, age, and education using per capita human capital by year, sex, age, and education as a weight. In mathematical terms, this is equal to

$$\text{Human capital stock in year } y = \sum_s \sum_a \sum_e (pcount_{y,s,a,e} \times life_{y,s,a,e})$$

where *life* is the per capita human capital stock, the sum of its market (*mi*) and nonmarket (*nmi*) components by year, age, sex, and education. The human capital stock is the total expected lifetime labor income—market and nonmarket—of the U.S. population.

Net investment in human capital is equal to the effects of changes from one year to the next in the size and distribution of the U.S. population on the human capital stock. This is mathematically equal to

$$\text{Net human investment} = \sum_s \sum_a \sum_e [(pcount_{y+1,s,a,e} - pcount_{y,s,a,e}) \times life_{y,s,a,e}]$$

Breaking down net human investment into its components

Since changes in the population can be broken down across different causes (births, deaths, and so on), we can break down net human investment into components corresponding to these causes. This account breaks net human investment into five components: investment from births; depreciation from deaths; net investment from education and aging of persons enrolled in school; depreciation from aging of persons not enrolled in school; and the net investment value of residual population shifts that cannot be explained with the available data on births, deaths, aging, and education.

Of these components, the most substantial deviation from other human capital accounts is the decision to measure investment in education net of the aging of persons enrolled in school rather than as a gross measure distinct from the aging of persons enrolled in school. This is because measured gross educational investment in this account is very sensitive to counterfactual assumptions; this sensitivity is discussed in the last section of the paper.

The Human Capital Stock

Applying the methods described above yields estimates of the human capital stock that, like those in Jorgenson and Fraumeni (1989, 1992), are very large. In 2006, assuming a discount rate of 4 percent and an income growth rate of 2 percent, the total stock of human capital was $738 trillion (table 1). Of that $738 trillion, $526 trillion—71 percent—is the present discounted value of nonmarket, nonschool time, while the remaining $212 trillion is the present discounted value of lifetime market earnings.The human capital stock is overwhelming in size compared with the stock of physical assets, which had a value of $45 trillion in 2006.[3]

3. The stock of physical assets is equal to the stock of fixed assets and consumer durable goods in table 1.1 of the Bureau of Economic Analysis fixed assets tables.

Table 1. Human Capital Stock

	Nominal (trillions of dollars)			Real (trillions of 2006 dollars)		
	Total	Market	Nonmarket	Total	Market	Nonmarket
1994	395	117	278	619	189	430
1995	411	122	288	627	192	436
1996	432	130	303	635	194	441
1997	454	138	316	642	196	446
1998	477	145	332	650	198	452
1999	505	155	350	658	201	458
2000	531	163	368	665	202	463
2001	557	170	388	673	205	469
2002	589	177	412	679	206	473
2003	648	185	464	686	208	478
2004	642	191	451	691	209	482
2005	667	200	467	697	211	487
2006	704	212	492	704	212	492

The share of the human capital stock that is nonmarket fluctuates between 69 percent and 72 percent. The ratio of the stock of human capital to the stock of physical assets was 18 in 1994 and 16 in 2006, and the proportion of investment that is nonmarket ranges from 70 percent to 77 percent and (using a regression on time) rises at a rate of 0.5 percentage point per year.

In real terms, the human capital stock increased at an annual rate of 1.1 percent between 1994 and 2006; the market component grew at a rate of 1.0 percent, while the nonmarket component grew at a slightly faster rate that rounds down to 1.1 percent. The real human capital stock is measured as a cost-weighted Fisher index of the U.S. population by age, sex, and education, using per capita human capital by age, sex, and education as the cost weight. Changes in this series over time can be attributed entirely to changes in the size of the U.S. population and changes in the distribution of the U.S. population by age, sex, and education. The growth in real human capital lagged growth in physical assets, which grew at an annual rate of 3.1 percent over the 1994 to 2001 period, of 2.6 percent over the 2001 to 2006 period, and of 2.9 percent over the entire 1994 to 2006 period.[4]

Growth in the human capital stock is very similar to growth in a simple headcount of the U.S. population, which also grew at a rate of 1.1 percent over the 1994 to 2006 period. This implies that virtually all growth in the human capital stock is a result of changes in the size of the U.S. population rather than in the distribution of the U.S. population by age, sex, and education.

4. Author's calculation from table 1.2 of the Bureau of Economic Analysis fixed assets tables.

Net Investment in the Human Capital Stock

Net investment in the human capital stock was $6.4 trillion in 2005, of which $1.6 trillion was investment in market human capital and $4.9 trillion was investment in nonmarket human capital (table 2).[5] By comparison, net investment in the physical capital stock equaled $1.0 trillion in 2005.[6] The nonmarket percentage of net human capital investment shows some volatility, ranging from 72 percent to 78 percent over 1994 to 2005. The general trend over time is toward a greater nonmarket proportion of investment; a simple regression of percent nonmarket on time implies that the percent nonmarket increases by 0.4 percentage point each year.

Table 2. Investment in human capital, 2005

(Trillions of dollars)

Component	Total	Market	Nonmarket
Net investment, total	6.1	1.6	4.5
Investment from births	9.3	3.2	6.1
Depreciation from deaths	2.6	0.4	2.2
Net investment from education, aging of enrolled	6.5	3.1	3.4
Depreciation from aging of nonenrolled	9.1	4.8	4.3
Residual net investment	2.0	0.4	1.5

The most important components of overall net human capital investment are investment from births and depreciation from aging of the nonenrolled; in 2005, births added $9.7 trillion to the human capital stock, while aging subtracted $9.5 trillion from the human capital stock. Net investment from education is the next most important component, adding $6.9 trillion to the human capital stock; recall that this not only includes the effects of education itself but also the effect of the aging of persons while enrolled in school. Deaths had a relatively small impact, subtracting $2.7 trillion from the human capital stock. The residual part of net investment has a relatively small value of $2.0 trillion, although it is also quite volatile. The relative importance of these components of net human capital investment remained roughly the same over the 1994 to 2005 period.

The importance of the different components of human capital differs substantively between net investment in the market component of human capital and net investment in the nonmarket component of human capital. Aging of the nonenrolled is the largest

5. Investment is measured for 2005 while the stock is measured for 2006 because the stock is measured at the beginning of the year; consequently, it is investment in 2005 that adds into the 2006 stock.

6. Author's calculation from tables 1.3 and 1.5 of the Bureau of Economic Analysis fixed assets tables; net investment of the physical capital stock is measured as investment in fixed assets and consumer durable goods minus depreciation in fixed assets and consumer durable goods.

contributor to (or, in this case, detractor from) the market component of human capital investment. Deaths are virtually irrelevant, since most people die well past their prime earning years. In contrast, the largest contributor to the nonmarket component of human capital is births.

Gross and Net Investment in Education

One shortcoming of this human capital account is the measurement of the contribution of education to human capital as net investment that includes the effects of the aging of the enrolled rather than gross investment that excludes the effects of aging. The account does not present measures of gross investment because of its sensitivity to assumptions about how persons who did enroll in school would have behaved in future years had they not enrolled in school. Gross investment in education in a given year is equal to the effect of school enrollment on the stock of human capital: the difference between actual human capital and what the stock of human capital would have been had no one enrolled in school that year. The latter depends substantially on what assumptions are made about the school enrollment decisions that people who actually did enroll in school would have made in future years had they not enrolled in school.

To illustrate this sensitivity, consider two different scenarios. The first scenario is similar to that of traditional human capital accounts. In this scenario, it is assumed that people who enrolled in school in real life would, in the counterfactual case of no enrollment for 1 year, become like people who did not enroll in school in real life. This has dramatic implications. Most persons who are enrolled in school are making normal progress in school enrollment with age and are "on track" to earn their high school diplomas at around age 18 or their bachelor's degrees at around age 22. People who are behind normal progress by a year or two are in a sense "off track," which has serious implications for eventual educational attainment. For example, in 1994, the probability that an "on track" 17-year-old male with an 11th grade education enrolls in 12th grade and finishes high school is 94 percent. If he misses a year of education and falls "off track" by 1 year, that probability drops to 79 percent; fall another year "off track," and it drops further to 30 percent. If we assume that persons who are "on track" would behave like persons who fall "off track" if they missed a year of education, the cost of missing a year of education is very large. Consequently, gross investment in education is extremely high.

In contrast, consider an alternative scenario. In this scenario, we assume that people who attended school in real life would not fall "off track" in the counterfactual of no enrollment for 1 year. Their likelihood of further enrollment would not drop; instead, they would enroll in further schooling at a rate equal to the enrollment rate of persons of the same education level who are 1 year younger. So, for example, consider again the 17-year-old male with an 11th grade education, whose probability of enrollment in 12th grade is 94 percent. If he did enroll in school, then we assume that had he not enrolled in school, his likelihood of enrollment in 12th grade as an 18 year old would still be 94 percent—and not 79 percent, which is the enrollment rate in 12th grade of actual 18 year olds with 11th grade educations. Consequently, the student stays "on track" toward finishing his diploma or degree when he misses a year of education; we assume in the counterfactual that his likelihood of enrollment in 12th grade is not affected by having missed a year. In this scenario, the cost of missing a year of education is much smaller, and as a result, gross investment in education is much smaller.

Under the assumption that persons who did enroll in school would have fallen "off track" had they not enrolled, the market component of gross investment in education in 2005 equals $16 trillion, greater than the entire gross domestic product (GDP) of the United States. In contrast, under the assumption that persons who did enroll in school would have stayed "on track" with a year's delay, the market component of gross investment in education in 2005 equals $3.1 trillion. Under this assumption, the market component of gross investment in education is still nearly four times greater than the measured output of education in traditional GDP accounts, which was $807 billion in 2005.[7] Substituting this measure of gross investment in education into GDP as a measure of the output of the education sector would increase total GDP by 18 percent (from $12.4 trillion to $14.7 trillion) and the share of education output in GDP from 6 percent to 21 percent—quite an impact for what is probably a conservative measure of human capital investment from education.

One possible reason for this result is that the analysis data set assumes that hourly earnings in adulthood only differ across five broad education categories: no high school diploma, high school diploma, some college, college degree, and advanced degree. Since this presumes a big payoff in earnings when one earns a

7. Author's calculation from tables 2.4.5 and 3.17 of the national income and product accounts of the Bureau of Economic Analysis; calculated as the sum of personal consumption expenditures on education and research ($226 billion) and government consumption expenditures on education ($581 billion).

degree, assumptions about whether people would stay "on track" or fall "off track" from earning their degrees are extremely important. A version of the analysis data set that takes into account incremental increases in earnings with increases in the level of education by individual year may yield estimates of investment in education that are less sensitive to counterfactual assumptions.

Conclusions

Like predecessor studies, this study finds that the size of the human capital stock in the United States is gigantic. When both market and nonmarket components of human output are combined, the stock of human capital was about three-quarters of a quadrillion dollars in 2006. About 70 percent of this stock is the nonmarket component. Net investment in human capital—which is primarily the effects of births, aging, and education—was about $6 trillion in 2005; the nonmarket share of investment is normally between 70 and 80 percent.

The human capital account produced is not entirely satisfactory since it does not produce conclusive measures of gross investment in education. The measures of gross investment in education are inconclusive because they are sensitive to counterfactual assumptions about what the future enrollment patterns of persons who are enrolled in school would have been had they not enrolled. Although the absence of conclusive measures of investment in education is disappointing, two interesting results come out of the analysis. First, it is useful to know that measures of gross investment in education can be very sensitive to the assumptions of the human capital account. Second, even the more conservative estimates of the market component of gross investment in education are nearly four times larger than the cost-based measures of educational output in the gross domestic product accounts.

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