

Fraumeni, Barbara M.; Christian, Michael S.

**Working Paper**

## Accumulation of Human and Market Capital in the United States, 1975-2012: An Analysis by Gender

IZA Discussion Papers, No. 12364

**Provided in Cooperation with:**

IZA – Institute of Labor Economics

*Suggested Citation:* Fraumeni, Barbara M.; Christian, Michael S. (2019) : Accumulation of Human and Market Capital in the United States, 1975-2012: An Analysis by Gender, IZA Discussion Papers, No. 12364, Institute of Labor Economics (IZA), Bonn

This Version is available at:

<https://hdl.handle.net/10419/202710>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

DISCUSSION PAPER SERIES

IZA DP No. 12364

**Accumulation of Human and Market  
Capital in the United States, 1975-2012:  
An Analysis by Gender**

Barbara M. Fraumeni  
Michael S. Christian

MAY 2019

## DISCUSSION PAPER SERIES

IZA DP No. 12364

# Accumulation of Human and Market Capital in the United States, 1975-2012: An Analysis by Gender

**Barbara M. Fraumeni**

*Central University for Finance and Economics, Hunan University, NBER and IZA*

**Michael S. Christian**

*Education Analytics*

MAY 2019

Any opinions expressed in this paper are those of the author(s) and not those of IZA. Research published in this series may include views on policy, but IZA takes no institutional policy positions. The IZA research network is committed to the IZA Guiding Principles of Research Integrity.

The IZA Institute of Labor Economics is an independent economic research institute that conducts research in labor economics and offers evidence-based policy advice on labor market issues. Supported by the Deutsche Post Foundation, IZA runs the world's largest network of economists, whose research aims to provide answers to the global labor market challenges of our time. Our key objective is to build bridges between academic research, policymakers and society.

IZA Discussion Papers often represent preliminary work and are circulated to encourage discussion. Citation of such a paper should account for its provisional character. A revised version may be available directly from the author.

ISSN: 2365-9793

**IZA – Institute of Labor Economics**

Schaumburg-Lippe-Straße 5–9  
53113 Bonn, Germany

Phone: +49-228-3894-0  
Email: [publications@iza.org](mailto:publications@iza.org)

[www.iza.org](http://www.iza.org)

## ABSTRACT

---

# Accumulation of Human and Market Capital in the United States, 1975-2012: An Analysis by Gender\*

This paper covers a continuous and longer time period than previously possible to examine human and market capital because of research by Christian (2017). This paper focuses on the presentation and analysis of trends in human capital by gender. During 1975-2012 there were significant changes in participation by women, the wage gender gap, and educational attainment and time in household production by both women and men. Both the market and nonmarket sectors will be covered as well as multifactor productivity with and without human capital. (A previous paper (Fraumeni, et al. 2017) described the national income accounting system which underlies both this paper and the much earlier paper by Jorgenson and Fraumeni (1989).) New insights will be gained by looking in detail at the 1975-2012 time period.

**JEL Classification:** J24, J16, O47, J22, I26

**Keywords:** human capital, differences by gender, production, multifactor productivity

**Corresponding author:**

Barbara M. Fraumeni  
770 Middle Road  
Dresden ME 04342  
USA

E-mail: [Barbara\\_Fraumeni@hotmail.com](mailto:Barbara_Fraumeni@hotmail.com)

---

\* A previous version of this working paper is forthcoming in Barbara M. Fraumeni, editor: Measuring economic growth and productivity: Foundations, KLEMS production models, and extensions, Academic Press, Cambridge, MA.

## Accumulation of Human and Market Capital in the United States, 1975-2012:

### An Analysis by Gender

Since the mid-seventies in the United States, there has been significant increases in female labor force participation including early-on during child-bearing ages, substantial change in total and by gender human capital arising from higher levels of both male and female educational attainment, a narrowing wage gender gap, and reallocation of time by both males and females. Including an analysis of human capital by gender points to many of the underlying causes of trends in economic growth; including human capital in national accounts is also critical to understanding any trends in economic growth. For example, when contributions to gross private domestic product with and without human capital, are examined, the 1995-2000 sub period looks less remarkable because investment in human capital is less important than in the previous sub period, while in the 2007-2009 sub period the impact of increases in investment in tertiary education by both males and females, among other factors, leads to healthier economic growth than would be expected during recession affected years. This paper, although presenting national accounts, emphasizes human capital factors by gender as these impact longer-term trends across sub periods.

Part I of this paper outlines human capital and national accounts methodology. Part II describes the underlying factors by gender. Part III presents national level accounts with and without human capital. Part IV looks at components of human capital by gender over time. Part V concludes.

#### Part I: Methodology

##### A: Human Capital

The human capital model employed in this paper is based on the model of Jorgenson and Fraumeni (1989, 1992). The Jorgenson-Fraumeni approach is often referred to as a lifetime-income approach, in which the human capital associated with a person is equal to his or her current and future lifetime earnings in present discounted value. The stock of human capital is equal to the sum of lifetime earnings across all persons in a population. Events that add to the stock of human capital (births, education, and immigration) are considered human capital investment, while events that subtract from the stock of human capital (deaths, aging, emigration) are considered human capital depreciation. Jorgenson and Fraumeni's (1989, 1992) measures of human capital include not only a market component based on lifetime earnings in market work, but also a nonmarket component based on time spent in nonmarket work, defined as time outside of market work, schooling, and personal maintenance, valued at an hourly opportunity cost equal to market wage adjusted for the marginal tax rate.

The specific human capital measures employed in this paper, which measure human capital in the United States from 1975 to 2012, are the same measures as in Christian (2017). In the nominal human capital measures, per capita human capital in year  $y$  for a person of sex  $s$ , age  $a$ , and years of education  $e$  is equal to

$$i_{y,s,a,e} = y i_{y,s,a,e} + (1+\rho)^{-1}(1+g)sr_{y,s,a+1}[senr_{y,s,a,e}i_{y,s,a+1,e+1} + (1 - senr_{y,s,a,e})i_{y,s,a+1,e}] \quad (22.1)$$

where

$s$  = sex (male or female);

$a$  = age (0 to 79);

$e$  = years of education (0 to 18);

$i_{y,s,a,e}$  = per capita lifetime income in year  $y$  of persons of sex  $s$ , age  $a$ , and years of education  $e$ ;

$y i_{y,s,a,e}$  = per capita yearly income in year  $y$  of persons of sex  $s$ , age  $a$ , and years of education  $e$ ;

$sr_{y,s,a}$  = survival rate in year  $y$  of persons of sex  $s$  from age  $a-1$  to age  $a$ ;

$\rho$  = discount rate;

$g$  = real income growth rate;

$senr_{y,s,a,e}$  = school enrollment rate in year  $y$  of persons of sex  $s$ , age  $a$ , and years of education  $e$ .

This approach measures lifetime income in a way that takes into account the probabilities of survival and of school attendance, both in the present and in the future. The primary source of data for measuring yearly income  $y i_{y,s,a,e}$  is the March demographic supplement of the Current Population Survey (CPS); that for measuring the school enrollment rate  $senr_{y,s,a,e}$  is the October school enrollment supplement of the CPS; and that for measuring the survival rate  $sr_{y,s,a}$  is the life tables of the Centers for Disease Control. It is assumed that school enrollment only takes place between ages 5 through 34 (at other ages,  $senr_{y,s,a,e} = 0$ ), and that income is only earned at ages 14 and older (at earlier ages,  $y i_{y,s,a,e} = 0$ ). As in Jorgenson and Fraumeni (1989), the real income growth rate  $g$  is assumed to be 2 percent, while the discount rate  $\rho$  is assumed to be 4 percent.

An exception to equation (1) is persons aged 80 and older. For these persons, per capita human capital is equal to

$$i_{y,s,80+,e} = [1 - (1+\rho)^{-1}(1+g)sr_{y,s,81+}]^{-1} y i_{y,s,80+,e} \quad (22.2)$$

This is the sum of an infinite series, and is equal to expected lifetime income given a yearly income  $y i_{y,s,80+,e}$  that increases at an annual rate of  $g$ , a constant rate of survival  $sr_{y,s,81+}$ , and a discount rate  $\rho$ .

To compute per capita human capital at a given age  $a$ , sex  $s$ , and level of education  $e$ , one begins by first computing per capita human capital for persons aged 80 and older using equation (2), and then working backwards to ages 79, 78, etc., all the way to age  $a$  by applying equation (1). To compute the stock of human capital, one computes the sum of per capita human capital times population across all combinations of age, sex, and education:

$$hc_y = \sum_s \sum_a \sum_e (pcount_{y,s,a,e} \times i_{y,s,a,e}) \quad (22.3)$$

where

$pcount_{y,s,a,e}$  = population in year  $y$  of persons of sex  $s$ , age  $a$ , and years of education  $e$ .

The change in the stock of human capital from one year to next can be broken out into net investment and revaluation as follows:

$$hc_{y+1} - hc_y = inv_{net(y)} + reval_y \quad (22.4)$$

where

$$inv_{net(y)} = \sum_s \sum_a \sum_e [(pcount_{y+1,s,a,e} - pcount_{y,s,a,e}) \times i_{y,s,a,e}] \quad (22.5)$$

and

$$reval_y = \sum_s \sum_a \sum_e [pcount_{y+1,s,a,e} \times (i_{y+1,s,a,e} - i_{y,s,a,e})] \quad (22.6)$$

Net investment in human capital is the effect on human capital of changes, from one year to the next, in the size and distribution of the population by age, sex, and education, weighted using lifetime earnings from the earlier of the two years. Revaluation is the change in the nominal value of lifetime earnings--the "price" of human capital--from one year to the next, weighted using the size and distribution of the population in the later of the two years.

In the measures used in this paper, net investment is not only measured as a whole, but also broken down into five components: investment from births; investment from education, net of aging while in school; depreciation from aging of persons not enrolled in school; depreciation from deaths; and residual net investment. These are equal to:

$$inv_{births(y)} = \sum_s [pcount_{y,s,0,0} \times i_{y,s,0,0}] \quad (22.7)$$

$$dep_{deaths(y)} = - \sum_s \sum_a \sum_e [pcount_{y,s,a,e}(1 - sr_{y,s,a+1}) \times i_{y,s,a,e}] \quad (22.8)$$

$$inv_{ed(y)} = \sum_s \sum_a \sum_e [pcount_{y,s,a,e}sr_{y,s,a+1}senr_{y,s,a,e} \times (i_{y,s,a+1,e+1} - i_{y,s,a,e})] \quad (22.9)$$

$$= \sum_s \sum_a \sum_e [(pcount_{y,s,a-1,e-1}sr_{y,s,a}senr_{y,s,a-1,e-1} - pcount_{y,s,a,e}sr_{y,s,a+1}senr_{y,s,a,e}) \times i_{y,s,a,e}]$$

$$dep_{aging(y)} = - \sum_s \sum_a \sum_e [pcount_{y,s,a,e}sr_{y,s,a+1}(1 - senr_{y,s,a,e}) \times (i_{y,s,a+1,e} - i_{y,s,a,e})] \quad (22.10)$$

$$= - \sum_s \sum_a \sum_e [(pcount_{y,s,a-1,e}sr_{y,s,a}(1 - senr_{y,s,a-1,e}) - pcount_{y,s,a,e}sr_{y,s,a+1}(1 - senr_{y,s,a,e})) \times i_{y,s,a,e}]$$

$$inv_{resid(y)} = inv_{net(y)} - inv_{births(y)} - inv_{ed(y)} + dep_{deaths(y)} + dep_{aging(y)} \quad (22.11)$$

Of the above components of net investment, two are substantive departures from the original Jorgenson-Fraumeni approach and deserve further discussion.

The first of these, investment in education, net of aging, is the combined effect of having both increased one year in age and one year in education while in school. This is different from the approach of the original Jorgenson-Fraumeni papers, which measured the effect on human capital from education alone. The effects of education and aging are combined here to avoid making the assumption that the future schooling outcomes of persons not currently enrolled in school (who, among children of school age, are falling "off track" of typical educational progress) are the same as what the future schooling outcomes of persons currently enrolled in

school would be in a counterfactual in which they were not currently enrolled in school. This assumption can lead to very high measures of gross educational investment, which are not robust to alternative assumptions (see Christian, 2010, for more discussion). It is useful to note that, because investment in education is measured net of aging, measures of depreciation from aging only include persons not enrolled in school.

The second of these, residual net investment, is the combined effect of net migration into and out of the United States and of measurement error. Net migration is included in residual net investment because, unlike births, deaths, education, and population, it is not measured in such a way as to be easily incorporated into the human capital account. Measurement error exists because the measures of births, deaths, education, and population used in the paper are not perfectly integrated, which means that there will be some differences in measured population from one year to the next that are not explained by births, deaths, aging, education, or migration.

When we measure gross investment, we include residual net investment, as well as investment from births and education:

$$inv_{gross(y)} = inv_{births(y)} + inv_{ed(y)} + inv_{resid(y)} \quad (22.12)$$

As in the original Jorgenson-Fraumeni accounts, both market and nonmarket components of human capital are measured. To measure these separate components, we begin by measuring market yearly income and nonmarket yearly income separately. Market yearly income is measured using average wage, salary, and self-employment income by year, age, sex, and education, using data from the March CPS. To measure nonmarket yearly income, we first compute per capita hours in nonmarket production, equal to per capita hours spent outside of market work, school (set to 1300 hours per year times the school enrollment rate), or personal maintenance (set to 10 hours per day) by age, sex, and education. This is multiplied by the hourly opportunity cost of not participating in market work, which is equal to the wage times 1 minus the marginal tax rate. We compute wages and hours in market work by age, sex, and education using the March CPS; school enrollment rates by age, sex, and education from the October CPS; and marginal tax rates using the Internet version of TAXSIM (Feenberg and Coutts, 1993). Combining market and nonmarket yearly income produces total yearly income:

$$yi_{y,s,a,e} \text{ (total)} = yi_{y,s,a,e} \text{ (market)} + yi_{y,s,a,e} \text{ (nonmarket)} \quad (22.13)$$

We compute market, nonmarket, and total lifetime income by alternatively using market, nonmarket, or total yearly income as the measure of yearly income  $yi_{y,s,a,e}$  in equations (1) and (2). Similarly, we compute market, nonmarket, and total human capital stock and investment by alternatively using market, nonmarket, or total lifetime income as the measure of lifetime income  $i_{y,s,a,e}$  in equations (3) through (12).

We compute real measures of the human capital stock by producing a chained Fisher volume index in which volume is population by age, sex, and education and weight is lifetime income by age, sex, and education. This is computed separately for market human capital, nonmarket human capital, and total human capital, using market lifetime income, nonmarket lifetime income, and total lifetime income as a weight. The real human capital stock in a given year  $y$  is



equal to the nominal human capital stock in the base year times the ratio of the value of the Fisher volume index in year  $y$  to the value of the Fisher volume index in the base year:

$$hc_y (\text{real}) = hc_{base} \times (F_y / F_{base}) \quad (22.14)$$

where  $F_y$  and  $F_{base}$  are values of the Fisher volume index in year  $y$  and in the base year. Real investment from births and education and depreciation from deaths and aging are similarly computed using a Fisher volume index that uses lifetime income as a weight and the terms multiplied by lifetime income on the right-hand sides of (7) through (10) as the disaggregated volume.

Real net investment is computed by subtracting the real stock of human capital from a one-year lead of the real stock:

$$inv_{net(y)} (\text{real}) = hc_{y+1} (\text{real}) - hc_y (\text{real}) \quad (22.15)$$

Real residual net investment is computed as the residual left over from real net investment after subtracting real investment from births and education and adding real depreciation from deaths and aging of individuals not enrolled in school.

## B. National Accounts

The national accounts methodology for all five national accounts is described in detail in Fraumeni et al. (2017).<sup>1</sup> In this paper, a 2009 production account is shown in Table 22.1.<sup>2</sup>

As in the “new architecture” accounts (Jorgenson and Landefeld, 2006, 2009), the core production account of the U.S. Bureau of Economic Analysis (BEA) national and income and product accounts (NIPA) is modified in a number of ways, but the estimates presented in this table, aside from the human capital components, are all but one from the U.S. BEA NIPA (U.S. Bureau of Economic Analysis, various dates). In the product account to allow for integration with productivity accounts, property-type taxes are included, but some other types of taxes, such as primarily sales taxes, are not included. Imputations for market capital services (see line 16 of the product account) add into gross private domestic product (GPDP) several capital services that are not in U.S. BEA NIPA Gross Domestic Product (GDP). These include those for consumer durables and real estate held by institutions and producer durable equipment held by institutions. The other imputation included in line 16 of the product account is the difference between the value of household real estate capital services real estate imputed in the “new architecture” accounts and that included in U.S. BEA NIPA GDP. These modifications are relatively minor in

<sup>1</sup> The five accounts are 1) production, 2) full (expanded) private national labor and gross national property income, 3) full (expanded) gross private national receipts and expenditures, 4) full (expanded) gross private national capital accumulation, and 5) full (expanded) private national wealth. Tables in the main body of Fraumeni, Christian, and Samuels (2017) outline the accounts; Appendix B of that paper presents the underlying data for 1948-84 and 1998-2009 for that previous version of the accounts.

<sup>2</sup> 2009 is the base year for the national income and product accounts of the U.S. Bureau of Economic Analysis (BEA). Table 22.1 comes from p. S396 of Fraumeni, Christian, and Samuels (2017), except for the human capital components: lines 18-21 of the entries under “product” and line 5 of the factor entries under “factor outlay.” These human capital components were computed by Christian for this paper.

scale. It is the human capital components (lines 18 through 21) that substantially change the magnitude of GPDP.

**Table 22.1 Production (billions of dollars)**

Product		<u>2012</u>
1	Gross national product (table 1.7.5, line 4)	16,497.4
2	- Rest-of-world gross national product (table 1.7.5, line 2 minus line 3)	252.9
3	- Compensation of government employees (table 6.2B, line 76 for 1982; table 6.2D, line 86 for 2009)	1,742.8
4	- Government consumption of fixed capital (table 5.1, line 17)	493.6
5	= Gross private domestic product (NIPA definition)	14,008.1
6	- Federal taxes on production and imports (table 3.5, line 2)	118.0
7	- Federal current transfer receipts from business (table 3.2, line 17)	28.7
8	+ Capital stock tax (table 3.5, line 12)	0.0
9	- State and local taxes on production and imports (table 3.5, line 13)	1,004.9
10	- State and local current transfer receipts from business (table 3.3, line 18)	41.9
11	+ Business property taxes (table 3.5, line 27)	440.0
12	+ Business motor vehicle licenses (table 3.5, line 28)	9.8
13	+ Business other taxes (table 3.5, sum of lines 29-31)	80.3
14	+ Subsidies less current surplus of federal government enterprises (table 3.2, line 32 minus line 19)	70.2
15	+ Subsidies less current surplus of state and local government enterprises (table 3.3, line 25 minus line 20)	14.8
16	+ Imputations for market capital services	789.0
17	= Gross private domestic product (Christensen-Jorgenson*)	14,218.7
18	+ Time in household production and leisure	14,886.0
19	+ Investment in human capital, births	9,916.3
20	+ Investment in human capital, education, net of aging	8,032.8
21	+ Investment in human capital, residual	2,258.9
22	= Expanded gross private domestic product	49,312.8

Factor Outlay		<u>2012</u>
1	Compensation of employees, all private industries (table 6.2B for 1982 and table 6.2D for 2009, both line 3)	6,877.2
2	+ Entrepreneurial labor income (imputation)	1,114.6
3	+ Property outlay (line 17 from the Product account, minus lines 1 and 2 from the factor outlay account)	6,226.9
4	= Gross private domestic factor outlay (Christensen-Jorgenson*)	14,218.7
5	+ Imputations for human capital from product account above (lines 18-21)	35,094.0
6	= Expanded gross private domestic factor outlay	49,312.8

Notes: Totals may differ slightly from the sums due to rounding. Table numbers refer to the National Income and Product Accounts (U.S. Bureau of Economic Analysis, various dates).

\*Christensen and Jorgenson developed what is called the U.S. Worksheets, which modified NIPA GDP and factor outlay as outlined above. The worksheets have never been published, but the earliest published production account using them appears on p. 23 of Christensen and Jorgenson (1970).

In the production account, human capital components appear both in product and factor outlay. Expanded consumption includes market consumption as well as time in household production and leisure.<sup>3</sup> Time in household production and leisure, which is valued at the market wage, excludes time in school and time in sleep and maintenance. Expanded (gross) investment includes market investment as well as investment in births, education, and the residual. Human capital components are part of labor factor outlay. In table 22.1, expanded labor factor outlay is equal to the sum of all components except for line 3: property outlay. Human capital labor factor outlay combines time in household production and leisure and human capital investment. As there are no human capital property factor outlay components, property outlay includes only market property outlay.

Net investment does not appear in the production account, but its components are of interest. Net investment is equal to investment (gross) which appears in the production account, minus depreciation due to aging of individuals not enrolled in school and deaths.

In nominal values, this period's human capital stock is equal to the stock in the previous period plus this period's net investment and the previous period's revaluation. Because some underlying estimates in the complete Christian (2017) data base, such as residual net investment, are negative, all real net investment estimates are constructed using additive aggregation.<sup>4</sup> In 2009 dollars, this period's human capital stock is equal to the stock in the previous period plus this period's net investment.

## Part II: Underlying Trends by Gender

As noted in the introduction, the period from the mid-seventies to 2012 is a period of significant changes impacting on human capital.

Between 1970 and 2010, there were relatively minor changes in the male civilian labor force rates by age, but significant changes in the female civilian labor force rates by age.<sup>5</sup> As figure 22.1 shows, between 1970 and 1980, the shape of the civilian female labor force participation rate by age profile changed significantly, from one in which the impact of child-bearing could clearly be seen to one in which this was no longer true. The apex of civilian female labor force participation rate by age profile rose by over 10 percentage points between 1970 and 1980 and again between 1980 and 1990, to end up at around 75 percent, before the whole profile showed minor changes between 1990, 2000, and 2010. As figure 22.2 shows, the apex of the male

---

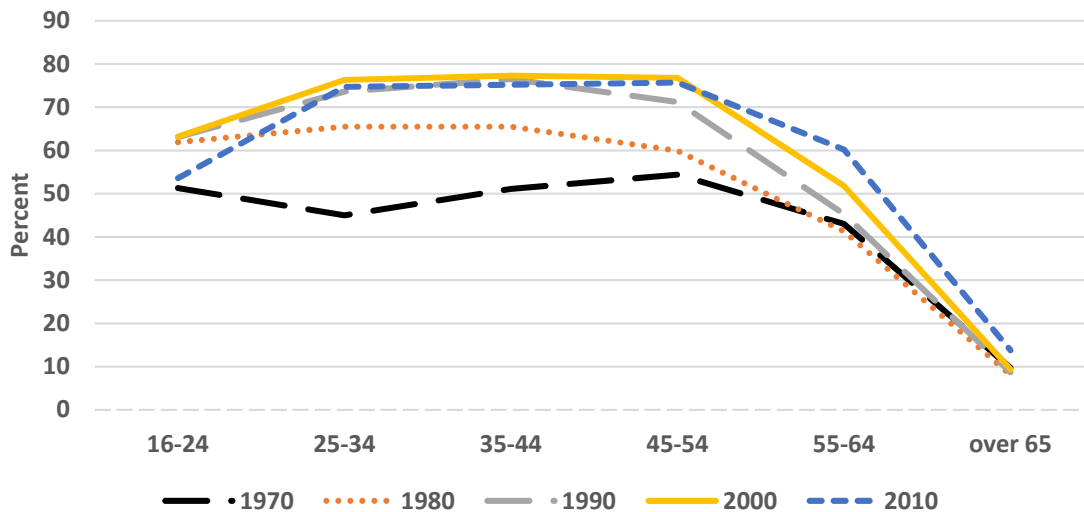
<sup>3</sup> The adjective “expanded” refers to constructs that include both human and market components. In previous published versions of this research (Jorgenson and Fraumeni, 1989; Fraumeni, Christian, and Samuels, 2017) the adjective “full” was used instead of the adjective “expanded.” In addition, the adjective “nonhuman” was frequently used when referring to market (nonhuman) components.

<sup>4</sup> However, contributions by gender to human components by market, nonmarket, and household production and leisure are constructed with a Törnqvist index as the totals for these categories are all positive numbers (for example, see Figure 22.8).

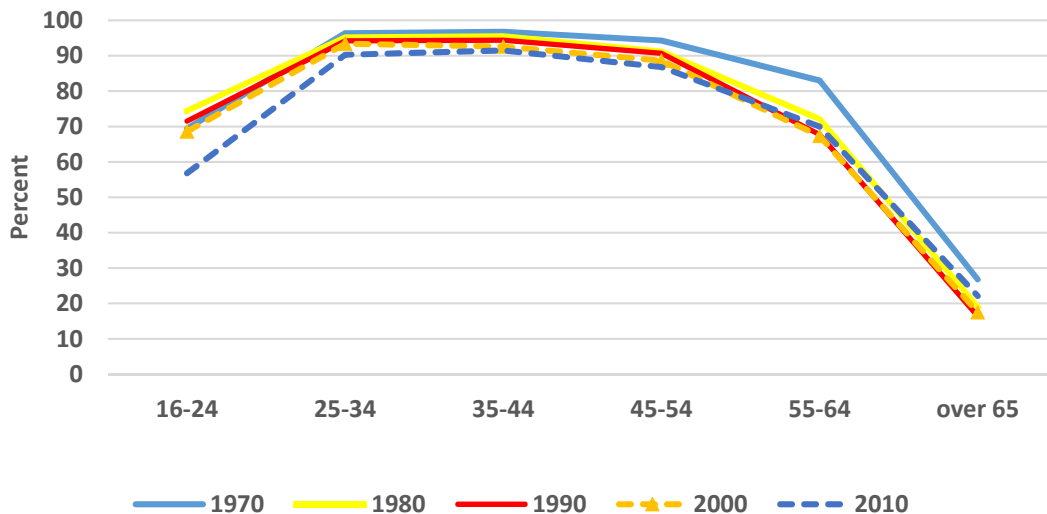
<sup>5</sup> The sources for figures 1 and 2 are: For years prior to 2010: U.S. Census Bureau, *Statistical Abstract of the United States: 2000*, Table no. 644. Civilian Labor Force and Participation Rates with Projections, 1970 to 2008, p. 403; for 2010: Toossi, Mitra “Employment outlook: 2010–2020, Labor force Projections to 2020: a More Slowly Growing Workforce” Table 3. Civilian labor force participation rates, by age, gender, race, and ethnicity, 1990, 2000, 2010, and projected 2020, U.S. Bureau of Labor Statistics, *Monthly Labor Review*, January 2012, pp. 50-51.

civilian male labor force profile did drop from around 95 percent in 1970, 1980 and 1990 to around 92 percent in 2000 and 2010.

**Figure 22.1: Civilian Female Labor Force Participation Rates 1970, 1980, 1990, 2000, and 2010**



**Figure 22.2: Civilian Male Labor Force Participation Rates 1970, 1980, 1990, 2000, and 2010**



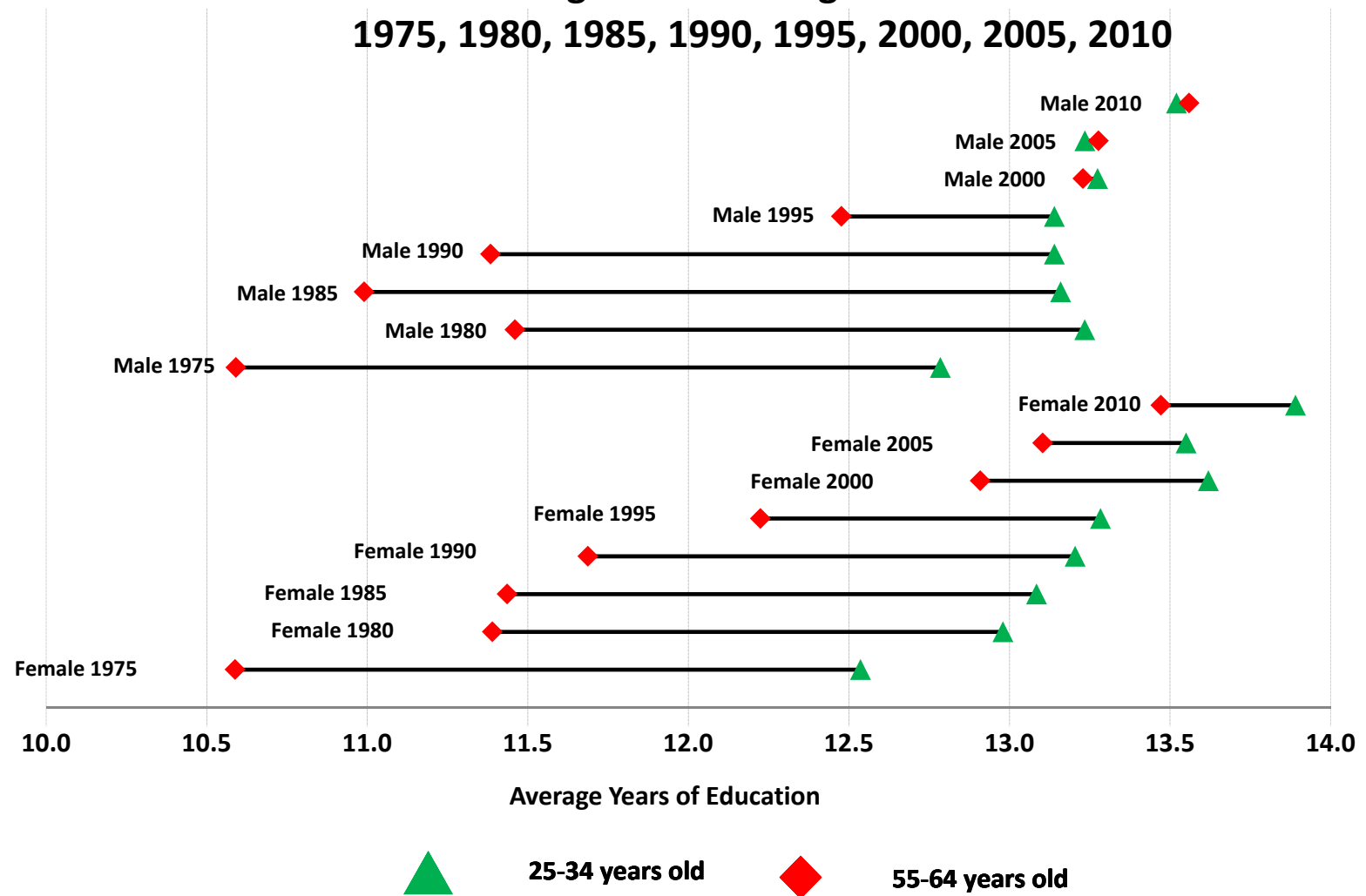
Over the period 1975 to 2010, average educational attainment for both males and females aged 15 and over increased substantially.<sup>6</sup> The difference between genders is at most .4 years of school; the average for both began in 1975 at about 11.5 years and ended at something just over 13 years in 2010. However, a comparison of average number of years of school by gender for those aged 25-34 versus 55-64 is striking. Until 1995 as figure 22.3 shows, the difference between years of school for the younger versus the older individuals is at least 1.5 years. Beginning in 1995 the difference decreases substantially for both genders, most notably starting in 2000 there is no appreciable difference between younger and older males. In fact, in 2005 and 2010, years of school of younger males is slightly less than for older males. In contrast, the number of years of school of younger females continues to be greater than for older females. By 2010, the years of school of younger females is greater than either that of younger or older males. It is expected that the female pipeline will lead to a higher 15 and over average for females than males as younger females age. This development is clearly in part a function of a larger percentage of 18 to 24 year old females than males enrolled in post-secondary degree granting institutions beginning in 1991 (figure 22.4).<sup>7</sup>

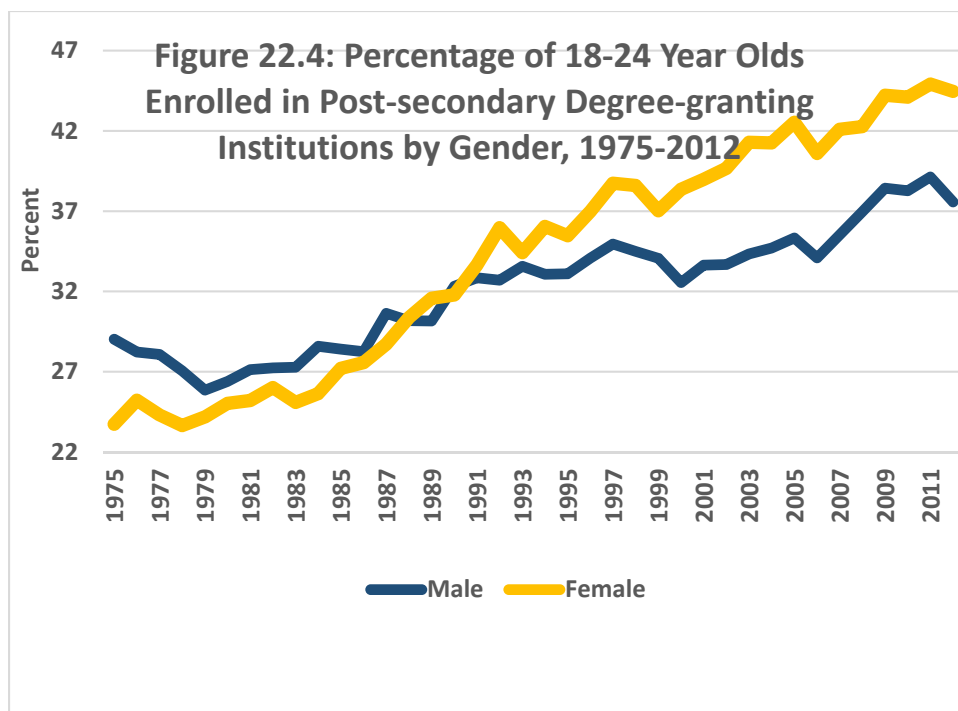
---

<sup>6</sup> The source of the educational attainment (years in school) data is Barro and Lee (2016).

<sup>7</sup> The source of the data underlying figure 22.4 is table 302.60 of the National Center for Education Statistics (NCES), *Digest of Education Statistics 2016*, [https://nces.ed.gov/programs/digest/d15/tables/dt15\\_302.60.asp](https://nces.ed.gov/programs/digest/d15/tables/dt15_302.60.asp), accessed March 15, 2018.

**Figure 22.3: Educational Attainment Comparisons by Gender**  
**Ages 25-34 vs. ages 55-64**  
**1975, 1980, 1985, 1990, 1995, 2000, 2005, 2010**





Between 1975 and 2012 the labor income gender gap narrowed.<sup>8</sup> The average income of a full-time year-round female worker as a percent of males rose from 56.2 percent in 1975 to 72.5 percent in 2012. The increase in the percent is not monotonic, notably it declined in 1999, 2000, and 2008. The percent peaked at 72.9 percent in 2007, subsequently hovering at around 72 percent from 2010 to 2012.

At the same time that females' average wages as a percent of males' rose, the allocation of time between market work and time in household production and leisure changed.<sup>9</sup> As a share of time excluding sleep and maintenance, in 1975 males on average spent a larger share of their time in school than females; the probability that a male was enrolled in school is greater than that for a female. By 2012, this share of time is almost equal for males and females because the probability that a female is enrolled in school caught up to that of males. Of greater interest are the changes in shares of time in market work and household production and leisure excluding time in school over this time period. It is not surprising that as a larger percentage of females moved into the labor force, they substituted market work time for household production and leisure time, to the tune of about .05 percentage point in the shares (see table 22.2). Males substituted household production and leisure time for market work time, but they reallocated their time on average to a much lesser degree as the change amounted to only .006 percentage point in the shares.

<sup>8</sup> Table P-37 of U.S. Census Bureau, *Current Population Survey, Annual Social and Economic Supplements*, Accessed online March 13, 2018. Note that individuals 15 years old and over beginning with March 1980, and individuals 14 years old and over as of March of the following year for previous years are included in the source table estimates.

<sup>9</sup> Time use and all human capital data, which was computed for this paper based on Current Population Survey data, comes from Christian.



<b>Table 22.2: Shares of Time in Market Work and Household Production of Leisure All Ages, Including Children, 1975 and 2012</b>				
	Male Hours Share		Female Hours Share	
	Market Work	Household Production & Leisure	Market Work	Household Production & Leisure
1975	.225	.775	.112	.888
2012	.219	.781	.164	.836

### Part III: National Level Accounts

Including human capital in any analysis is key to understanding economic growth. Figures 22.5 and 22.6 show the growth accounting components with and without human capital.<sup>10</sup> On the output side, the contributions to economic growth are those from consumption and investment. On the input side, the contributions to economic growth are those from capital, labor, and change in multifactor productivity growth. Figure 22.6 includes the expanded GDP components, while figure 22.5 does not. As table 22.1 shows, the expanded GDP human capital components, which include investment in education, net of aging, time in household production and leisure, and the residual, are very large relative to GDP. Growth in human capital components depends upon population growth by category, and increasing levels of education and wage growth as reflected in lifetime income weights. These all grow slowly compared to GDP. According to the World Bank, U.S. population growth from 1975-2012 averaged 1.04 percent per year.<sup>11</sup> Human capital estimates in this paper assume a real labor income growth rate of 2 percent per year. The progress in raising the average number of years in school for the population 15 and over (Barro and Lee, 2016) is notable, the increase per year averages at most .4 percent per year from 1975-2010. The average rate of growth in real GDP is 2.9 percent per year from 1975-2012.<sup>12</sup> Individuals are more highly educated on average, but population growth is slow. Accordingly for the whole period 1975 to 2012, it is not surprising that the rate of growth of GDP excluding human capital is almost double that of expanded GDP including human capital (see table 22.3); in addition, the 1976 to 2012 contribution of multifactor productivity change excluding human capital is about three times that in the accounts including human capital.<sup>13</sup>

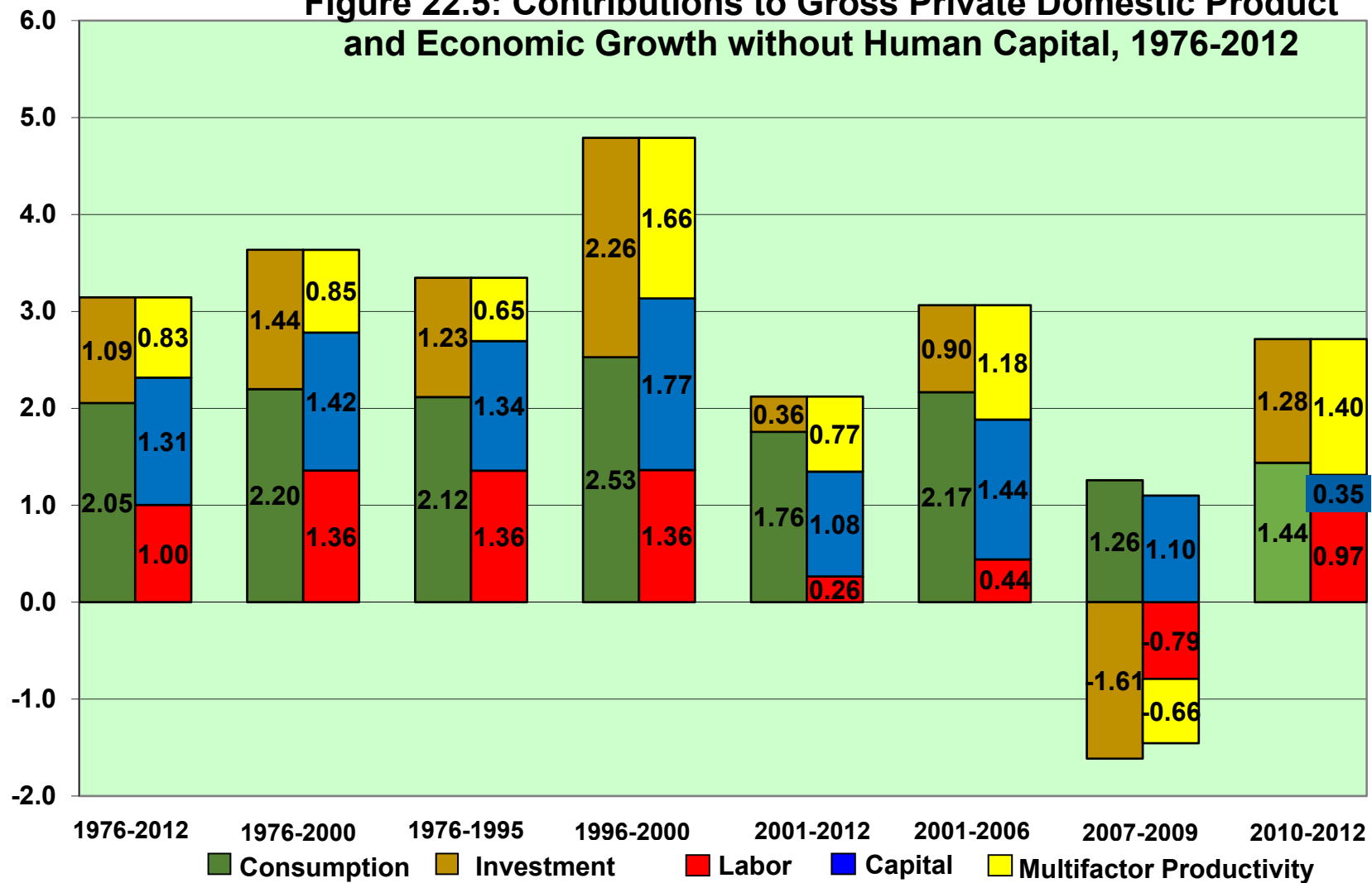
<sup>10</sup> All real estimates in this paper combining human and market components are constructed with a Törnqvist index.

<sup>11</sup> World Bank, World Bank Indicators, last updated March 1, 2018, accessed online April 14, 2018.

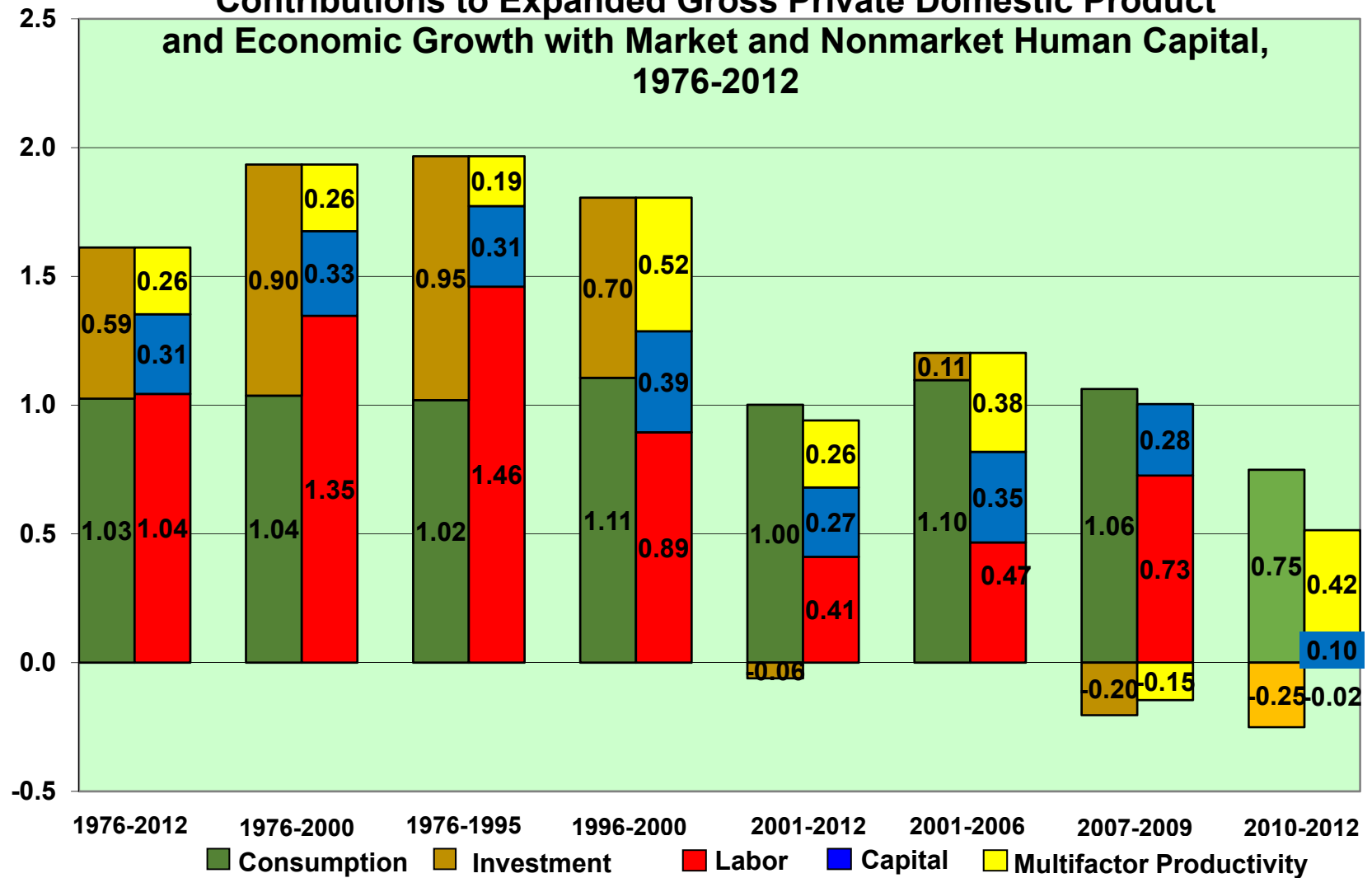
<sup>12</sup> U.S. BEA NIPA, table 1.1.1, accessed April 14, 2018.

<sup>13</sup> As the quantities of human capital investment and time in household production and leisure on the output side appear as nonmarket labor input on the input side, human capital components do not contribute to multifactor productivity.

**Figure 22.5: Contributions to Gross Private Domestic Product and Economic Growth without Human Capital, 1976-2012**



**Figure 22.6:  
Contributions to Expanded Gross Private Domestic Product  
and Economic Growth with Market and Nonmarket Human Capital,  
1976-2012**



<b>Table 22.3: Real Rate of Growth of Gross Private Domestic Product (GDP)</b> <b>without Human Capital, with Market Human Capital and with Market and Nonmarket Human Capital, 1975-2012</b>						
Years	Real Rate of Growth of GDP			Ratio of Growth Rates of GDP		
	Without Human Capital	With Market Human Capital Only	With Market and Nonmarket Human Capital	Without Human Capital to with Market Human Capital	Without Human Capital to with Market and Nonmarket Human Capital	With Market Human Capital to with Market and Nonmarket Human Capital
1975-2012	3.14	2.20	1.61	1.43	1.95	1.37
1975-2000	3.64	2.58	1.93	1.41	1.88	1.34
1975-1995	3.35	2.53	1.97	1.32	1.70	1.29
1995-2000	4.79	2.80	1.81	1.71	2.65	1.55
2000-2012	2.12	1.41	.94	1.51	2.26	1.49
2000-2006	3.06	1.64	1.20	1.87	2.55	1.37
2006-2009	-.36	.97	.86	-.37	-.42	1.14
2009-2012	2.71	1.36	.50	1.99	5.45	2.73

In all sub periods starting with 1996 or later there are notable differences in the contributions with and without human capital as well changes in the relative growth rate of GDP across sub periods.<sup>14 15</sup> Between 1995 and 2000 and 2000 and 2006, the quantity of human capital investment either rose slightly or fell. As figure 22.3 shows, 1995 is the year in which the average years of school of 25 to 34 year olds compared to 55 to 64 year olds for both genders narrowed. In subsequent years, as previously noted, there is almost no difference in years of school for the younger and older males. The sub period 1996-2000 is a remarkable time for the impact of computers on economic growth, but not for human capital investment.<sup>16</sup> When human capital is included, there is little difference between this and previous sub periods. In 2001-2006, the contribution of investment including human capital is only one-tenth of consumption including time in household production and leisure.

During the 2007 through 2009 Great Recession years, tertiary enrollment and time use by both men and women differs compared to other sub periods.<sup>17</sup> Changes in tertiary enrollment percentages and time use shares by either gender are small or nonexistent in the prior and the later sub period. From 2006 to 2009, the percentages of individuals aged 18 to 24 enrolled in a post-secondary degree-granting institution increased substantially and the share of time devoted to work dropped by almost the identical amount that the share of time in household production and leisure increased as the share of time devoted to school stayed almost constant. From 2006 to 2009, the percent of 18-24 year-old males enrolled in a post-secondary degree-granting institution increased by 4.3 percentage points from 34.1 to 38.4 percent; for females the comparable figures are 3.6 percentage points from 40.6 to 44.2 percent.<sup>18</sup> Over the same period, considering time devoted to household production and leisure and market work, the male share

---

<sup>14</sup> In the “Contributions to Expanded Gross Private Domestic Product and Economic Growth” charts, the following growth rates are included in the calculation of contributions by sub periods.

1976-2012	1975-6...2011-12
1976-2000	1975-6...1999-2000
1976-1995	1975-6...1994-1995
1996-2000	1995-6...1999-2000
2001-2012	2000-1...2011-2
2001-6	2000-1...2005-6
2007-9	2006-7...2008-9
2010-12	2009-10...2011-12

<sup>15</sup> Contributions are calculated as a weighted rate of growth of quantities in logs, where the weights are the average share of this period’s and last period’s nominal values. The multifactor productivity change contribution is the exception as it is the rate of growth of the quantity of output minus the contributions of all inputs.

<sup>16</sup> Human capital investment in education occurs when individuals are in school.

<sup>17</sup> The official dates for the “Great Recession” from the National Bureau of Economic Research Business Cycle Dating Committee are December 2007 (peak) to June 2009 (trough). Annual growth rates in real GDP declined substantially from 2004 through 2007, accordingly it is not surprising that time use and enrollments are impacted beginning in 2007. U.S. BEA NIPA real GDP annual growth rates are: 3.8 percent in 2004, 3.3 percent in 2005, 2.7 percent in 2006, and 1.8 percent in 2007.

<sup>18</sup> Table 302.60, NCES, *Digest of Education Statistics 2016*.

[https://nces.ed.gov/programs/digest/d15/tables/dt15\\_302.60.asp](https://nces.ed.gov/programs/digest/d15/tables/dt15_302.60.asp), accessed March 15, 2018.

of time devoted to household production and leisure (market work) rose (decreased) by 2.4 percentage points; for females the comparable figure is .8 percentage points.

From 2007-9, as shown in the output side of the contributions charts, the contributions of both consumption and investment are larger in absolute value terms when human capital is excluded, however output growth is positive only when human capital is included. The increase in tertiary enrollment is a positive investment in education, net of aging, contribution to economic growth as is the increase in consumption from a larger share of time devoted to household production and leisure. In addition, from 2006-9, in spite of the recession beginning in late 2007, the quantity of market consumption increases, while the quantity of market investment as expected decreases substantially.

During the same period, the fact that human labor input is so large relative to market labor input, ranging from about 80 to 83 percent of total nominal labor input, changes the growth picture substantially. Human labor input is set equal to human capital investment, including the residual, plus time in household production and leisure. First, the positive contribution of human labor input outweighs the negative contribution of market labor input. Second, although in both charts capital input is all market capital input, because the share of market capital input is much smaller in the chart including human capital given the large magnitude of human labor input, the contribution of capital to output is substantially less than in the chart without human capital. The contribution of multifactor productivity change is negative both with and without human capital, but it is substantially less negative when the positive influence of human labor input is factored into the analysis. The contribution of multifactor productivity change is negative both with and without human capital, with the contribution of multifactor productivity change without human capital being more than four times more negative than that with human capital.

In the next sub period: 2010-12, market investment recovers; the quantity of market investment increasing by about 25 percent between 2009 and 2012, but the quantity of human investment declines by over 4 percent in the same time period. On net, expanded labor input decreases, and capital input (which is all market) increases, and the contribution of multifactor productivity growth to growth in expanded GDP is almost a full percentage point less than the contribution of multifactor productivity growth to growth in GDP, excluding human capital.

For comparison, tables 22.3 and 22.4 and figure 22.7 include estimates with only market human capital. Time in household production and leisure is excluded from the market human capital estimates. In addition, the magnitudes of the market human capital estimates are lower than those which include nonmarket human capital. The largest absolute difference between market and total human capital is for investment in human capital from births because the difference in lifetime income is accumulated over more years than for individuals of specific ages (table 22.4). However, total input or output contributions from market human capital are greater than those which include nonmarket human capital (table 22.3). This is because the total human capital expanded GDP components are a far larger percentage of adjusted GDP than those for market human capital (table 22.4). As the first paragraph of this section explained, expanded components normally have a lower rate of growth than NIPA or adjusted GDP.

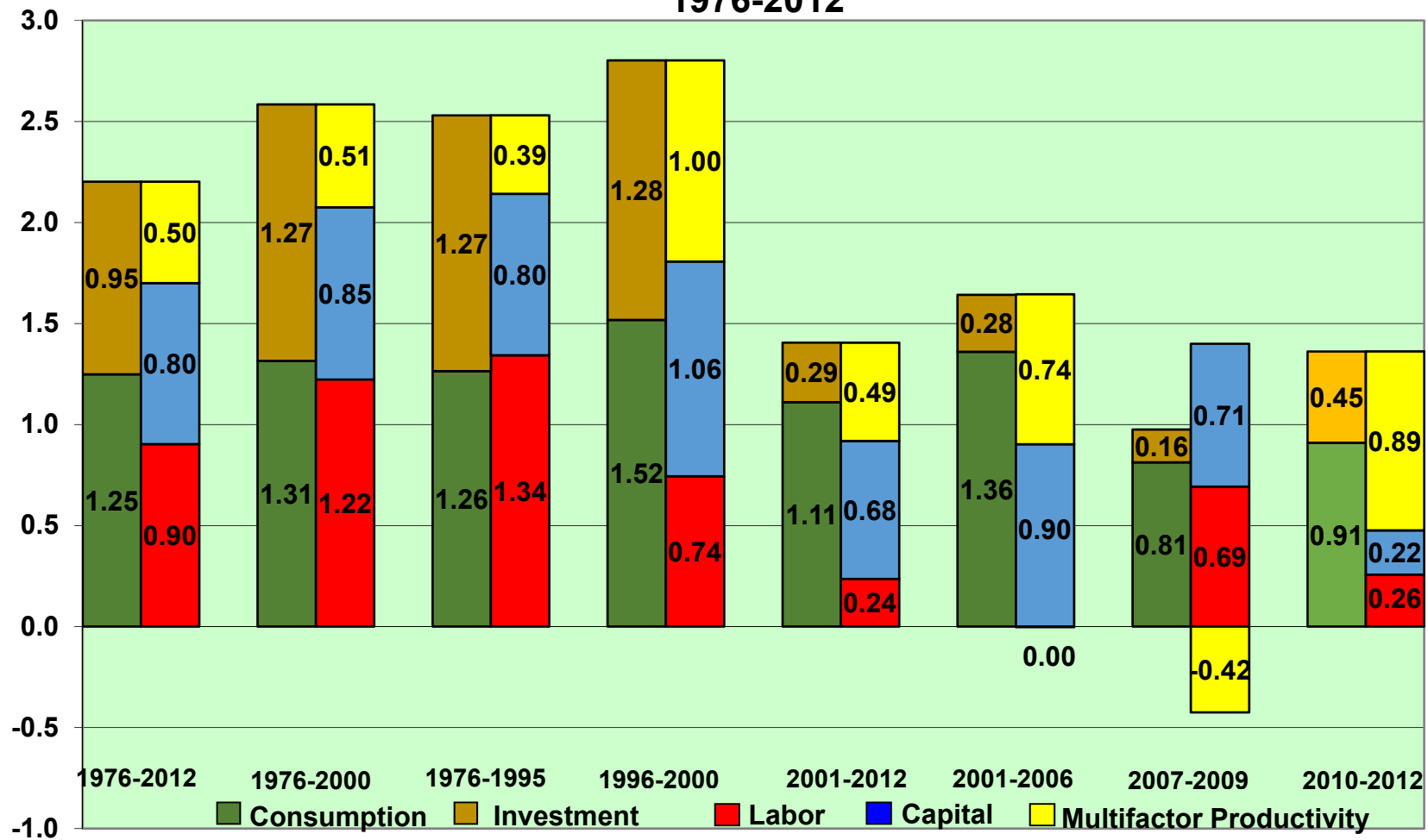
**Table 22.4: Comparison of Production Magnitudes with Market Human Capital Only and Total Human Capital Production, United States, 2012**

	Market Human Capital			Total Human Capital		Ratio of Total to Market
	billions	percent		billions	percent	
Gross private domestic product (NIPA definition)	14,008	63		14,008	28	1.0
Gross private domestic product (adjusted)	14,219	64		14,219	29	1.0
+ Time in household production and leisure	0	0		14,886	30	undefined
+ Investment in human capital, births	3,340	15		9,916	20	3.0
+ Investment in human capital, education, net of aging	4,080	18		8,033	16	2.0
+ Investment in human capital, residual	704	3		2,259	5	3.2
=Expanded gross private domestic product	22,343	100		49,313	100	2.2

The overall level and individual components of the contributions vary significantly between the two constructs as figures 22.6 and 22.7 illustrate. Except in the sub period 2007-9, total contributions are largest for the account without human capital, followed by market human capital only, then total human capital (table 22.3). Typically, the share of contribution of labor input to input growth and the share of contribution of consumption to output growth is less with market human capital only than with total human capital, as nonmarket labor input and time in household production and leisure are excluded in the market human capital only version. The exceptions occur in a 2001-2012 sub period when one or more contribution is negative. Multifactor productivity for market human capital only is always greater than for multifactor productivity when nonmarket human capital is included, except during the last sub period 2009-12. As this paper illustrates, time periods starting after 2000 exhibit different features than those for the earlier sub periods.



**Figure 22.7: Contributions to Expanded Gross Private Domestic Product and Economic Growth with Market Human Capital Only  
1976-2012**



#### Part IV: Human Capital Components by Gender

Delving into the components of human capital investment and stock and allocation of time by gender reveals additional trends over time. Gross investment is the sum of births, education, net of aging, and residual components (equation 22.12). Net investment subtracts depreciation due to aging of individuals not enrolled and deaths. Both investment and stock can be separated into market and nonmarket components. The nonmarket component includes human capital investment and time in household production and leisure. As residual net investment and some elements of detailed investment by gender, age, and education can be negative, contributions cannot be calculated for human capital gross or net investment except by market human and nonmarket human components.

In most cases between 1975 and 2012, male nominal investment shares and stock shares of totals for the country generally trend downward and female nominal shares generally trend upward. In all cases, the pace of the share changes slowed sometime in the nineties and the percent change between 1975 and 2012 is larger for females than for males. It is not surprising that the biggest percent change in any share at 15.8 percent is for female investment in births (see table 22.5), however the female percent changes for investment in education, net of aging, depreciation due to deaths, and human capital stock are all between 13.4 and 14.0 percent. No female share of total for the country is at or above 50 percent, but all but one are close to 45 percent or above by 2012. All female shares begin in the range of about 35 to 40 percent. The largest decrease in the male percent share is for investment in births, foretelling future changes in human capital stocks.

Table 22.5: Human Capital Components Nominal Shares, 1975 and 2012						
	Gross Investment		Investment in Births		Investment in Education, Net of Aging	
Year	Male	Female	Male	Female	Male	Female
1975	.592	.408	.614	.386	.611	.389
2012	.556	.444	.553	.447	.556	.444
	Depreciation				Stock	
	Aging From Individuals Not Enrolled in School		Deaths			
	Male	Female	Male	Female	Male	Female
1975	.590	.410	.651	.349	.591	.409
2012	.545	.455	.604	.396	.537	.463

Table 22.2 demonstrated that women are spending less of their time in household production and leisure, but the nominal share of household production and leisure, relative to market and nonmarket human capital investment nominal shares, has increased (see table 22.6). This occurs as a result of wages paid to women rising by more than enough to compensate for the reduction in time. In table 22.6, three-way and two-way nominal shares are both presented. Although the share of male nonmarket human capital is essentially unchanging between 1975 and 2012, it is in part because there is a reallocation of time between market work and time in household production and leisure as table 22.2 shows.<sup>19</sup> In both two-way and three-way comparisons, the female market and nonmarket human capital investment nominal shares remain substantially below those for men compared to the time in household production and leisure nominal share. In addition, in both comparisons, the female nominal share of time in household production and leisure remains substantially above those for men.

<b>Table 22.6: Human Capital Investment and Time in Household Production &amp; Leisure, Nominal Shares, 1975 and 2012</b>						
Year	Male			Female		
	Market Human Capital	Nonmarket Human Capital	Time in HH Production & Leisure	Market Human Capital	Nonmarket Human Capital	Time in HH Production & Leisure
1975	.316	.333	.351	.165	.416	.419
2012	.266	.331	.403	.191	.360	.449
	Male			Female		
	Market Human Capital	Nonmarket Human Capital		Market Human Capital	Nonmarket Human Capital	
1975	.487	.513		.284	.716	
2012	.446	.554		.347	.653	

Examining real net investment components: investment in births and education, net of aging, residual, and aging from individuals not enrolled in school and death depreciation, underscores gender and sub period differences. In absolute value terms, the size of the real net investment components are significantly different between the first major sub period: 1975-2000, and the second: 2001-2012. Figure 22.8 shows that the positive and negative components for both genders become significantly larger.<sup>20 21</sup> The increasing levels of education, particularly tertiary education, influence both investment in education, net of aging, and investment in births, the latter as the expectation of higher future enrollments increases newborns expected lifetime income. In 2000, although the average years of school of males aged 25-34 is almost the same as

<sup>19</sup> The nominal value of time in household production and leisure only depends on time spent today and the current market wage. Since market and nonmarket human capital are lifetime income constructs, there are a number of factors which affect their nominal value, such as expected future education, number of working years, and survival rate. The real income growth rate is 2 percent for all future years.

<sup>20</sup> The sum of the real net investment percent shares sum to 100, but in figure 22.8 the percent shares are divided by 100 to fit them within the bars. Accordingly, the percent shares in figure 22.8 sum to 1.0.

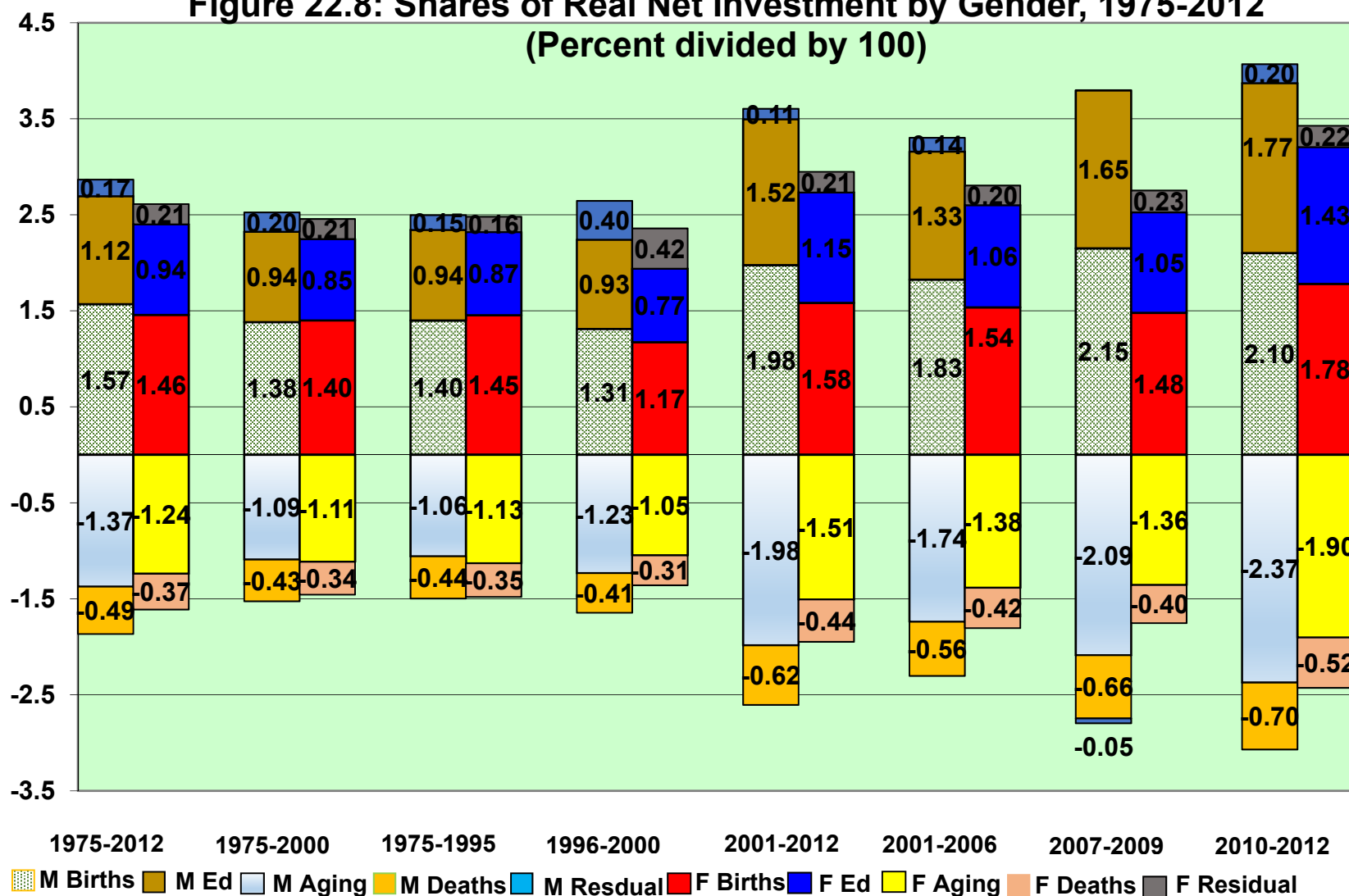
<sup>21</sup> Contributions cannot be computed by these components of real net investment as residual investment is negative in a number of years. For the same reason, net investment is computed with additive aggregation.

the average years of school of males aged 55-64, the average years of school for those younger is substantially greater than it is in 1995 (figure 22.3). Female average years of school for those aged 25-34 continued to increase over the second major sub period. As individuals age, their lifetime income decreases as they have fewer years before they die. Baby boomers births, those born between mid-1946 and mid-1964, which created a demographic bulge, by 2001 are between 37 and 55 years of age, and by 2012 are between 48 and 66 years of age.<sup>22</sup> Accordingly, it is not surprising that the male share of real net investment for both aging for individuals not enrolled in school and death depreciation becomes more negative in each of the sub periods 2001-2006, 2007-9, and 2010-12. Although the female share of net investment for aging for individuals not enrolled in school and death depreciation does not become more negative in each of the three sub periods, these shares are significantly more negative than those for the first major sub period. In general, depreciation from aging for individuals not enrolled in school is greater for more highly educated individuals than for less highly educated individuals. Women live longer than males on average and are becoming more highly educated, but even in 2010 older males are more highly educated on average than older females (figure 22.3).

---

<sup>22</sup> Colby and Ortman (2014).

**Figure 22.8: Shares of Real Net Investment by Gender, 1975-2012**  
(Percent divided by 100)



Another way to examine gender differences is to consider contributions of the expanded GDP components: market human capital net investment, nonmarket human capital net investment and time in household production and leisure net investment to human components by gender as shown in figure 22.9.<sup>23 24</sup> In all but the earliest lowest level sub period: 1976-1995, for both genders, there are at least some negative contributions, but the time in household production and leisure contribution is always positive. As the time that men spend in household production and leisure is going up, it is expected that the contribution of this component will be positive. The fairly consistent downward trend in female time in household production and leisure per capita ends in 2000, yet female total time in household production and leisure increases in all years as population growth more than offsets the decrease in time per capita. In the 2007-2009 sub period the contribution of male time in household production and leisure is substantially larger than it is for other years. In the same sub period, the female contribution is larger than in any other sub period. In both cases, the cause is a reallocation time away from market work time to time in household production and leisure during the U.S. Great Recession as already described. Beginning in 1996-2000, for both genders, the contribution of market and nonmarket net investment in human capital is negative or very small, except in 2007-2009. Investment in education, net of aging, which occurs only when individuals are in school, is one of two positive additions to net investment in human capital. As previously described, 2007-2009 is a sub period in which the percentage of individuals 18-24 who enrolled in tertiary education increased substantially. However, between 2009 and 2010, this enrollment leveled off, before decreasing between 2011 and 2012. From 1975 to 1990, births increased in every year but two.<sup>25</sup> Subsequently births declined from 1990 through 1997, then increased in most years, but then declined again from 2007 through 2012.<sup>26</sup> The impact of the decrease in births starting in 2007 is most felt in nonmarket net investment in human capital. It is not surprising that births decreased during the recession because of the uncertainty the recession created. In 2010-2012, the rate of growth of the quantity of net investment is a negative 1.1 percent for males and a negative 4.1 percent for females. In this sub period, the share of real net investment for both depreciation from ageing for individuals not enrolled in school and death are significantly larger than for any other sub period, reflecting the aging of the baby boomers.

---

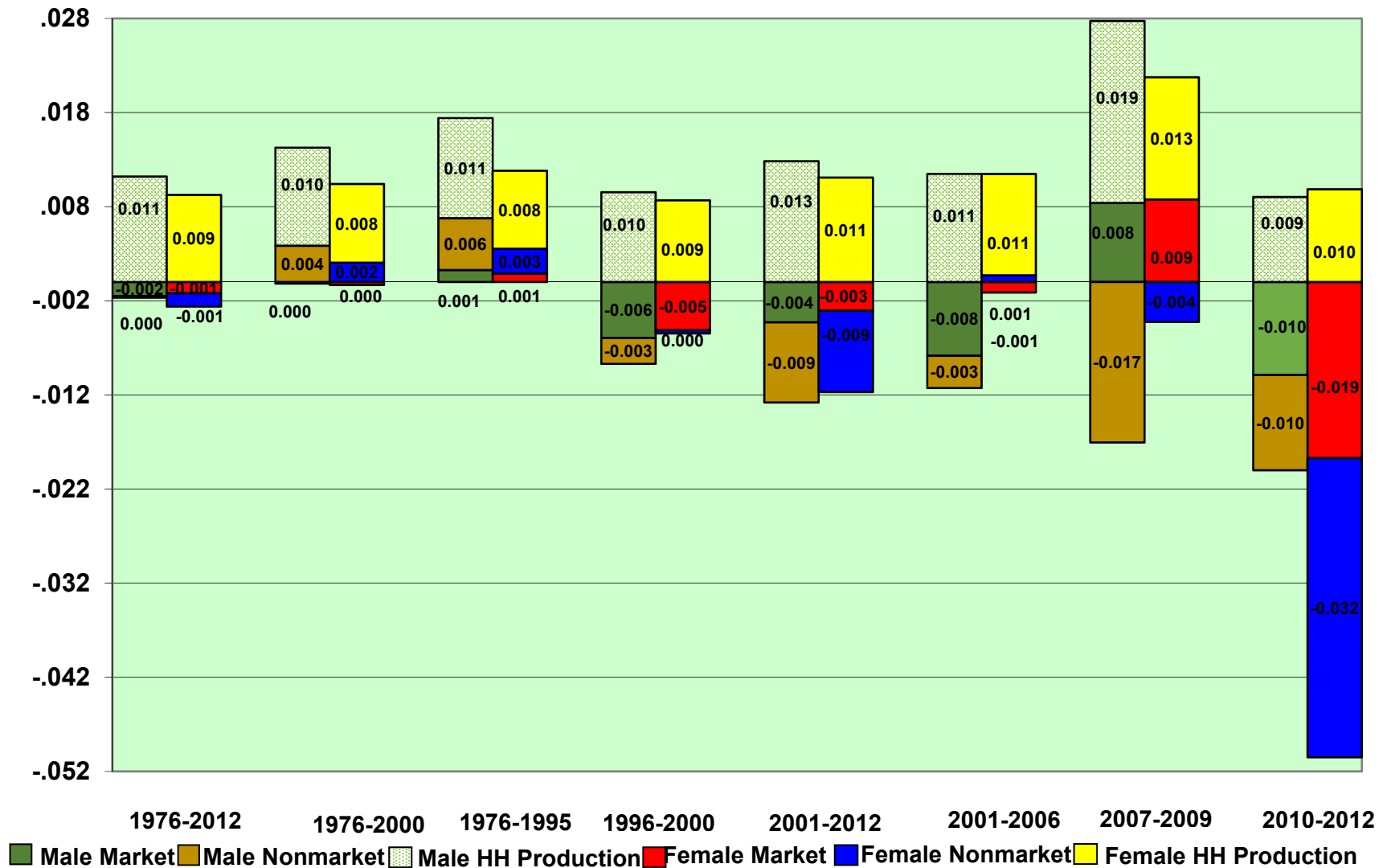
<sup>23</sup> These contributions can be presented as nonmarket labor outlay is estimated with a Törnqvist index from the aggregate quantities of market and nonmarket human capital investment and time in household production by gender, which are always positive.

<sup>24</sup> The investment in human capital, residual, is included in the respective net investment totals.

<sup>25</sup> U.S. Census Bureau, *Statistical Abstract of the United States: 2012*, Section 2: Births, Marriages, and Divorces, Table no. 78. Live Births, Deaths, Marriages, and Divorces: 1960 to 2008, p. 65.

<sup>26</sup> Hamilton and Kirmeyer, 2017.

Figure 22.9: Expanded GDP Contributions by Gender, 1975-2012



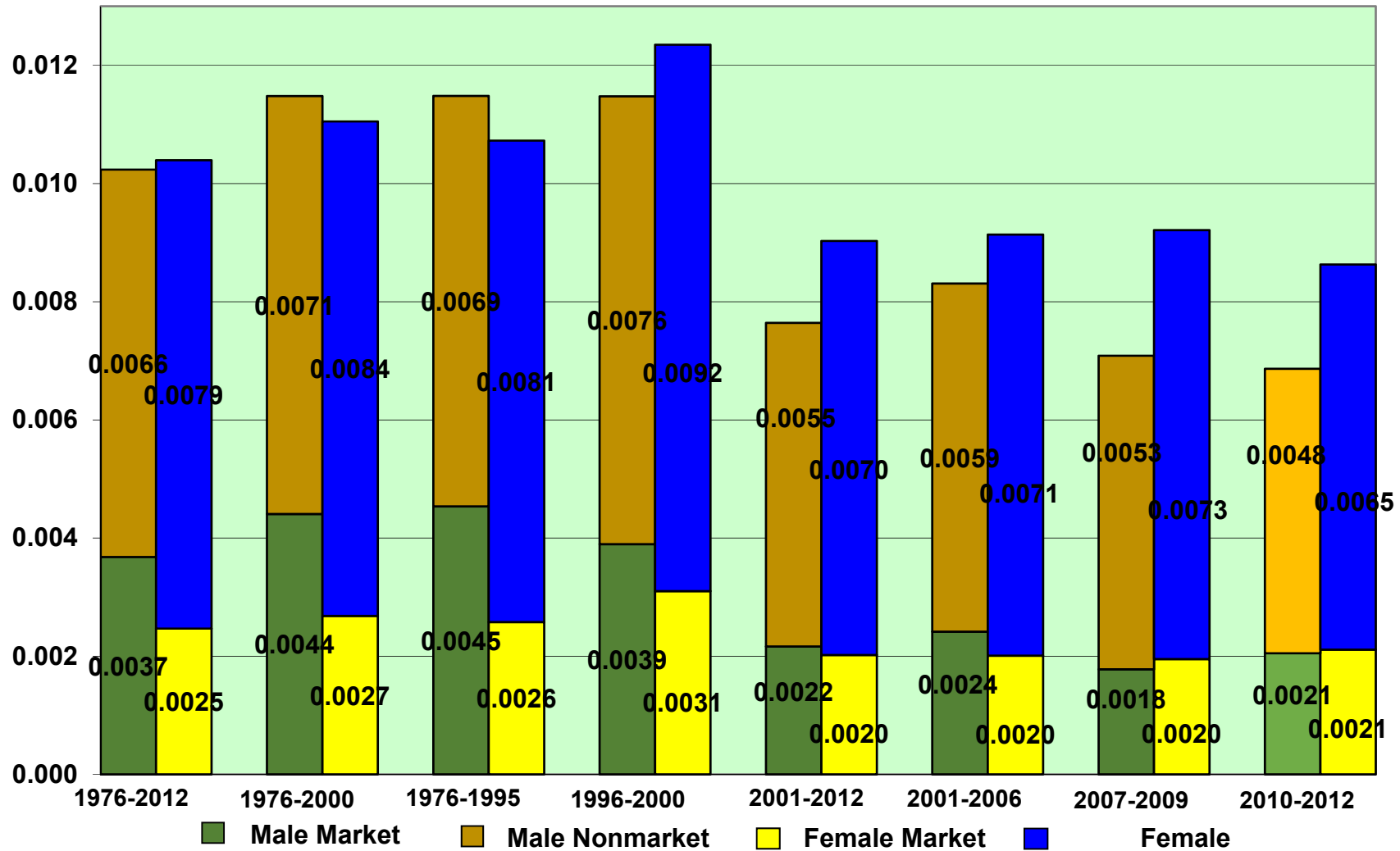
The final figure shows the contribution to human capital stock by gender (see figure 22.10). Growth in human capital stock slows during the later sub periods beginning in 2000, primarily for demographic reasons. During this time population growth is slowing and baby boomers are aging. Even during the earlier sub period: 1975-2000, when population growth is higher, population growth still averages only 1.1 percent.<sup>27</sup> Accordingly, contributions to human capital stock are all fairly small. Investment in education, net of aging, is still an important source of growth in the stock, but the pace of increases in educational attainment, particularly among those 25-34, has slowed. Female labor force participation and the ratio of females to male wages stagnates by the end of this second major period. It is notable that female human capital stock contributions exceeds that of males in each of the sub periods beginning in 1996. There are clear differences between the first major sub period: 1975-2000 and the second: 2001-2012. Between 1975 to 2000 and 2001 to 2012, the male market contributions dropped by .15 percentage points and the male nonmarket contribution dropped by .11 percentage points. Between the same two periods, the female market contribution dropped only .04 percentage points and the female nonmarket contribution by just .09 percentage points. In addition, the share of male market contributions in total male contributions fell by over 16 percentage points; the female market share of contributions to human capital stock also dropped, but only by just over 2 percentage points. As figure 22.6 previously demonstrated, there are clear differences between the earlier major sub period and the second.

---

<sup>27</sup> World Bank, World Bank Indicators, last updated March 1, 2018, accessed online April 14, 2018.



**Figure 22.10: Human Capital Stock Contributions by Gender  
1975-2012**



## Part V: Conclusion

This paper has documented that there have been significant changes in human capital in the United States over the period 1975-2012. Analysis by gender points out that although changes in male human capital occur, the changes in female human capital arising from significant underlying trends in labor force participation, educational attainment, relative wages, and time use are even greater. In addition, the first major sub period: 1975-2000, typically looks quite different than the second major sub period: 2001-2012. The future is more likely to look like the second major time period: 2001-2012, than the first: 1975-2000, as the underlying trends have not continued to more recent years. Without an analysis including human capital and an analysis by gender, important elements of past, present, and potential future economic growth in the United States would be missed.

## Bibliography

Barro R, Lee JW: Barro-Lee educational attainment data set, last updated February 2016. (website) [www.barrolee.com](http://www.barrolee.com). Accessed May 2018, 2016.

Christensen LR, Jorgenson DW: U.S. real product and real factor input, 1929-1967, *Review of income and wealth*, 16(1):19-50, 1970.

Christian MS: Human capital accounting in the United States, 1994-2006, *Survey of Current Business* 90(6):31-36, 2010.

Christian MS: Net investment and stocks of human capital in the United States, 1975-2013, *International productivity monitor* 33:128-149, Fall 2017.

Colby SL, Ortman JM: The baby boom cohort in the United States: 2012 to 2060, *Population estimates and projections*, Current Population Reports, P25-1141, May 2014.

Feenberg D, Coutts E: An introduction to the TAXSIM model, *Journal of policy analysis and management* 12(1):189-194, 1993.

Fraumeni BM, Christian MS, Samuels JD: Accumulation of human and nonhuman capital, revisited, *Review of income and wealth*, 63 (Suppl 2):S381-S410, 2017.

Hamilton BE, Kirmeyer SE: Trends and variations in reproduction and intrinsic rates: United States, 1990–2014, *National Vital Statistics Reports*, 66 (2), February 22, 2017.

Jorgenson DW, Fraumeni BM: The accumulation of human and nonhuman capital, 1948-1984. In R. Lipsey and H. Tice editors: *The measurement of saving, investment and wealth*, Chicago, 1989, University of Chicago Press, NBER, pp 227-282.

Jorgenson DW, Fraumeni BM: The output of the education sector. In Griliches Z, editor: *Output measurement in the service sectors*, Chicago, 1992, University of Chicago Press, NBER, pp 303-341.

Jorgenson DW, Landefeld JS: Blueprint for expanded and integrated U.S. accounts: review, assessment, and next steps. In DW Jorgenson, JS Landefeld, WD Nordhaus, editors: *A new*

*architecture for the U.S. national accounts*, Chicago, 2006, University of Chicago Press, NBER, pp 13-112.

Jorgenson DW, Landefeld JS: Implementation of a New Architecture for the U.S. National Accounts, *American Economic Review, Papers and Proceedings*, 99(2):64-68, May 2009.

National Bureau of Economic Research: US business cycle expansions and contractions. (website) [www.nber.org/cycles.html](http://www.nber.org/cycles.html). Accessed July 9, 2018.

National Center for Education Statistics: *Digest of education statistics: 2016* (website). [nces.ed.gov/programs/digest/d15/tables/dt15\\_302.60.asp](http://nces.ed.gov/programs/digest/d15/tables/dt15_302.60.asp). Accessed March 15, 2018.

Toossi M: Employment outlook: 2010–2020, labor force projections to 2020: a more slowly growing workforce, *Monthly labor review*, January:50-51, 2012.

U.S. Bureau of Economic Analysis: *National income and product accounts*, Washington, D.C., U.S. Department of Commerce, (website). [www.bea.gov](http://www.bea.gov). Accessed April 14, 2018.

U.S. Census Bureau: *Current population survey, annual social and economic supplements* (website). [www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-people.html](http://www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-people.html). Accessed March 13, 2018.

U.S. Census Bureau: *Statistical abstract of the United States: 2000*, Washington, DC, U.S. Census Bureau (website). [www.census.gov/library/publications/2000/compendia/statab/120ed.html](http://www.census.gov/library/publications/2000/compendia/statab/120ed.html). December 2000.

U.S. Census Bureau: *Statistical abstract of the United States: 2012*, Washington, DC, U.S. Census Bureau (website). [www.census.gov/library/publications/2011/compendia/statab/131ed.html](http://www.census.gov/library/publications/2011/compendia/statab/131ed.html). Accessed April 23, 2018

World Bank: *World Bank indicators*, Last updated March 1, 2018 (website). [data.worldbank.org/indicator/SP.POP.TOTL?locations=US&view=chart](http://data.worldbank.org/indicator/SP.POP.TOTL?locations=US&view=chart). Accessed April 14, 2018.