Explaining The Worldwide Boom in Higher Education of Women*

Gary S. Becker, William H.J. Hubbard, and Kevin M. Murphy

November 2009 draft

1. Introduction and Evidence of the Boom

The worldwide boom in higher education since 1970 has been truly remarkable. Figure 1 divides about 120 countries into the top and bottom halves in terms of per capita incomes. It then shows for each set of countries the average fraction of 30-to-34-year-olds with higher education from 1970 to 2010. The figure shows, not surprisingly, that men and women in poorer countries are much less likely to get a higher education than persons in richer countries. However, both richer and poorer countries had significant growth in the fractions with higher education during that thirty-year span. By 2000, over 22 percent of persons 30-34 years old in richer countries had college education, while over 7 percent of persons in poorer countries had a higher education at the beginning of this century (up from less than 3 percent in 1970). By 2010, the figures will be 27 percent and 11 percent, respectively.

We interpret the increased propensity to get a higher education all over the world as reflecting greater benefits relative to costs from having a college education. The most obvious benefit relates to earnings, and many studies have shown that the earnings premium from a college education increased during the past several decades in many countries. Other benefits from going to college include better health, better marriage prospects, more effective investments in children, and more effective responses to unexpected events, such as a devastating hurricane or greater employment risk due to global competition.

Indeed, it is difficult to mention any type of behavior or any kind of activity where college educated persons do not have a considerable advantage over persons who did not go to college. The differences between the haves and the have-nots, especially in richer countries, in good part come down to whether a person went to college or not. We will catalogue these benefits later, and show that these benefits of college education have risen over time.

Given the great breadth of benefits that college education provides, and the fact that these benefits have been rising over time, a worldwide rise in college education is not surprising. What *is* striking, however, is the different responses of men and women to the rising benefits of college. In the United States, rates of college completion among men have been almost flat since the 1970s, while college completion among women has risen steadily and rapidly during the same period. See Figure 2. In 2007, over 57 percent of bachelor's degrees were awarded to women. NCES (2008a). Nor is the overtaking of men by women in higher education a phenomenon unique to the United States. Figure 3 shows the average fraction of 30-

* In preparing this paper, we had excellent research assistance from Jeff Picel.

to 34-year-old men and women with higher education in 1970 and 2000, using the same sample of countries as Figure 1. Women's education still lagged that of men in lower income countries in the year 2000, although the gap had narrowed considerably since 1970. In the richer countries, however, by 2000 a larger fraction of women were obtaining a college education than men.

Figures 4–6 plot the gender difference (women minus men) in the fraction of 30- to 34-year-olds with college attainment against per capita GDP. A positive gender difference was a novelty in 1970, essentially reserved for a few of the wealthiest countries. By 2000, a larger fraction of women than men had completed higher education in 50 of 120 of the countries, including countries from every populated continent and 14 countries with below-median per capita GDP. By 2010, these figures will rise to 67 countries, including 17 lower-income countries.

In order to illuminate the worldwide boom in higher education, and in particular higher education of women, Section 2 presents a model of the optimal investment in college by an individual. The determinants include not only the lifetime earnings gain from going to college, but also the effects of college on health, on marital prospects, on productivity of investments in children, and also on the ability to cope with uncertainty. The incentive to go to college also depends on the costs of college, incorporating forgone earnings as well as tuition, the difficulty of financing these costs, and the ease or difficulty of performing well in college.

Section 3 presents some evidence from the United States on various benefits of college for men and women. The evidence is strong that college benefits of men and women increased over time in essentially all the dimensions that we measure. Although some of the college benefits increased faster for women than men, the benefits from college are still lower for women in most dimensions. Yet women finish school at much greater rates than men do.

Section 4 presents evidence on the costs, and in particular on the difficulty of college, for men and women. Evidence on grades in school indicate that women have both higher grades on average than men, and a smaller inequality in their grade distribution. We argue that because of these gender differences in the costs of school, the supply of women to college is more elastic than that of men with respect to changes in monetary returns (i.e., more responsive to changes in the monetary benefits of college) than the supply of men to college. Perhaps too the supply of women to college is now greater at any given monetary benefits than the supply of men.

Section 5 develops our analysis further as we move from the individual to equilibrium in the market for college-educated men and women. The demand for college graduates clearly has been growing over time, and so has the supply of men and women that go to college. In recent decades, demand has grown faster than supply, so that the college earnings premium has grown quite substantially. We argue that women have overtaken men in going to and graduating from college partly because the elasticity of supply of women with respect to the college earnings premium exceeds that of men, and partly because perhaps the net benefits from

going to college are now greater for the average female high school graduate than the average male.

2. Optimal Investment by an Individual

This section considers the optimal investment in "college" education, S, by different individuals. The production of S is determined by

1) $S = F(h, H, A_c, A_n)$

where h is the time spent at college, A_c and A_n measure cognitive and non-cognitive abilities, and H measures the stock of human capital prior to any investment in S. H, A_c, and A_n are parameters when investing in college that varies among individuals depending on their earlier education and their abilities. The output of S is increasing in all these predetermined inputs into the production of S, so that F_h, F_H, F_c, and F_n are all >0. F may not be everywhere concave in h, or even continuous in h because of graduation premia. However, we assume that around the optimal level of h, $F_{hh} < 0$. The cost of the time spent investing in S depends on the earnings forgone per hour of h.

We assume reasonably that all the inputs into S are complements. This implies, in particular, that F_{hH}, F_{hc}, and F_{hn} are all >0. That is, abler students are more efficient at using their time to produce a college education, and hence they have stronger incentives to continue in school. We ignore any effects of abilities on how much students like college, although analytically such effects would be largely subsumed under the effects of abilities on the productivity of investments in college.

Investments in college take place in the initial period only, and produce benefits in a single future period. College education S has many future benefits that compensate for the investment costs. We divide these benefits into raising earnings, improving survival rates, raising the utility from consumption, and improving marital prospects. Raising utility from consumption includes the effects of college education on quality of health, investments in children, management of financial assets, adjustment to shocks, and on other forms of consumption.

Each individual chooses an investment in college education that maximizes his discounted expected utility, given by

2) $V = U_1(x_1, l_1; H) + p(S; H)\beta U_2(x_2, l_2, S; H),$

where β is his discount rate. The coefficient p is his probability of surviving to the end of period 2, where p is assumed to depend positively on his human capital, as measured by both S and H. The variable x measures the consumption of goods, and l measures household time. Utility is assuming to be increasing and concave in x, l, H, and S.

Utility is maximized subject to resource constraints, and these constraints are crucial to the analysis. To simplify the discussion we assume there is full annuity insurance, so that expected discounted consumption, including spending on S, would

equal expected discounted income. Subject to this equality, individuals can borrow and lend at the interest r. We ignore any difficulties in using investments in college as collateral to finance consumption. The full wealth budget constraint over the two periods is then

$$3)\quad x_1 + \frac{px_2}{1+r} + w_1 l_1 + \frac{pw_2(S,H)l_2}{1+r} + T + w_1 h = w_1 + \frac{pw_2(S,H)}{1+r} + \frac{pM(S)}{1+r} = W,$$

where W is expected full wealth, w refers to hourly earnings, and the total time in each period is normalized to 1. The LHS shows how full wealth is spent, where T is tuition and fees, and $w_1 h$ is the earnings forgone from being in college.

Since college education raises hourly earnings in the second period, the derivative $w_{2s} > 0$. This derivative measures the hourly earnings returns per increment of college education, and may vary with the amount of college education. College education also improves well-being by raising the likelihood of marrying persons with greater education and other attractive characteristics. The expected gain from marriage in the second period is treated as an increment to expected wealth, $p(S)M(S)$. Since the gain from marriage is generally greater for those with a college education, $M_s > 0$.

Individuals maximize the value of their discounted utility V in eq. 2, subject to the full wealth constraint in eq. 3. The variables of interest are investments in college human capital (S),the time spent investing in this capital (h), consumption in each period (the x's), and hours spent in household production (the l's). The FOCs for consumption are the usual ones

$$4)\quad U_{1x} = \mu, \quad \text{and} \quad p\beta U_{2x} = \frac{\mu p}{1+r}$$

The assumption of full annuity insurance means that the probability of surviving the second period (p) drops out of the FOC for x_2, so that uncertainty nowhere enters these conditions. Hence the usual arbitrage condition

$$5)\quad \beta U_{2x} = \frac{U_{1x}}{1+r}$$

The FOCs for time spent in the household are also standard, as in

$$6)\quad U_{1l} = \mu w_1, \quad \text{and} \quad p\beta U_{2l} = \frac{\mu p w_2}{1+r}$$

The probability of survival in period 2 also drops out of these time allocation FOCs. The LHS of these FOC's give the marginal utility of allocating more time to the household sector, while the RHS gives the marginal cost of taking time away from earnings.

We are mainly interested in the FOCs for investments in college education. If e_2 is hours worked in period 2, the FOC for the optimal time spent in college is given by

$$7)\quad \frac{\mu p e_2 w_{2s} F_h}{1+r} + p\beta F_h U_{2s} + \beta p_s F_h U_2 + \frac{\mu p M_s F_h}{1+r} + \frac{\mu p_s F_h M}{1+r} + \frac{\mu p_s F_h [e_2 w_2 - x_2]}{1+r} = \mu w_1$$

If we divide through by μ, the marginal utility of consumption in period 1,and by F_h, the marginal productivity of the time spent investing in college, we get

$$8)\quad \frac{pe_2w_{2s}}{1+r}+\frac{p\beta U_{2s}}{U_{1x}}+\frac{\beta p_s U_2}{U_{1x}}+\frac{pM_s+p_sM}{1+r}+\frac{p_s[e_2w_2-x_2]}{1+r}=\frac{w_1}{F_h}$$

The RHS of eq.8 gives the marginal cost of producing an additional unit of a college education, *S*. The numerator equals the hourly earnings forgone when spending an additional hour at college, and the denominator equals the marginal product of this time. The marginal cost of producing an additional year of college also depends negatively on cognitive and non-cognitive abilities, and past investments in schooling and other human capital because of the complementarity among the inputs used to produce college human capital. By raising the marginal cost of increasing *S*, lower cognitive or non-cognitive abilities reduce the optimal investment in college education, partly by lowering grades and other measures of performance in college.

The probability of surviving through the second period does not drop out of the FOC for investments in education since the survival probability affects expected future benefits. This is the source of the well-known complementarity between life expectancy and investments in schooling, so that an increase in the probability of surviving in the future raises the incentive to invest in schooling.

The first term on the LHS of eq. 8 gives the discounted expected increase in earnings from greater college education. This is the term that dominates discussion of "rates of return" to education in the economics of education literature. This measure of the "rate of return" to college education increased greatly in the United States and many other countries during the past 30 years. The wage premium of college graduates compared to high school graduates increased since 1980 from about 40% to about 80%.The total benefits from college increases also with hours worked (e_2), while they decrease with the interest rate (r).

The second term on the LHS of eq. 8 gives the effect of greater college education on the expected increase in utility from future consumption. If college raises utility by raising the efficiency of household time—just as college raises hourly earnings by raising the efficiency of market time—the effect of greater time in college on future utility can be written as

$$9)\quad \frac{\partial U_2(x_2,\varphi(H,S)l_2)}{\partial h}=\varphi_s F_h l_2 U_{2l},$$

where φ converts S (and H) into effective household time. Then the effect on utility is determined by the product of three forces: the amount of household time, the increase in the effective amount of each hour of household time due to college education, and the marginal utility of effective household time. In this case, the effects on earnings and utility of greater college education are a weighted average of the increases in earnings and the utility, with the weights being the time allocated to the market and household sectors, respectively. Allocating more time to the market sector increases overall returns to education only if market benefits from

greater education exceed household benefits. We return to this issue later on in discussing returns from college education to women compared to men.

The third term on the LHS of eq. 8 measures the increase in expected utility due to the effect of greater education on the probability of surviving in the future. Using the FOC for x_2, this term can be written as

$$10)\ \frac{p_s\beta U_2}{U_{1x}} = \frac{p_s\beta U_2}{\beta(1+r)U_{2x}} = \frac{p_s U_2}{U_{2x}(1+r)}$$

A generalization to multiple periods of the term $U_2/U_{2x}(1+r)$ is called "the statistical value of life," for it measures how much an individual is willing to pay for a unit increase in his probability of surviving in the future. This value is in monetary units; for a young male in the United States it is estimated to be in the $3-7 million range.

The fourth term on the LHS of eq. 8 measures the effect of a college education on benefits in the marriage market. These benefits include the effects of college education on the probability of marriage, and the effects of marriage on utility and earnings. The latter effects occur because marriage is a productive activity that directly raises the combined full wealth of spouses. The sharing of this greater full wealth between them depends on various individual characteristics and marriage market conditions, such as the number of men and women seeking to get married, how many men and women have a college education, the demand for children, and many other variables (see Becker (1991) and Chiapporri, Iyigun,and Weiss (2009)). Marital benefits are usually neglected in studies of the returns to education, even though they are often important.

The fifth term in eq. 8 measures the benefit from an increased probability of survival in the future if future earnings exceed future consumption. This is a benefit since an increase in the probability of survival when future earnings exceed future consumption raises possible consumption in the initial period. This difference between earnings and consumption was the main effect emphasized in early studies of the value of life since it was supposed to measure the net contribution of an individual to the resources of society. Clearly, that analysis was misguided since the contributions of education to earnings and utility, and to the statistical value of life, could be highly important even if spending in each post-investment period equaled income in the same period, or more generally, if the present value of spending post-investment equaled the present value of earnings.

3. Gender Differences in the Benefits of College

This analysis of an individual's optimal investment in a college education suggests that differences in the propensities of men and women to go to and graduate from college depend on gender differences in the magnitude of total benefits from college relative to gender differences in the full cost of attending college. We first discuss benefits, and concentrate our attention on differences between men and women in the effects of college on earnings, life expectancy, the propensity to marry and to stay married, and the effects of parental education on children's education.

3.1 College Wage and Earnings Premiums

Presumably, men and women are substitutes in the labor market, so that an increase in the supply of either male or female college graduates would lower the earnings of both male and female graduates. This does not mean, however, that their working times substitute hour for hour. Since women earn less than men at each education level, labor markets are valuing an hour of women's time at less than that of men, although this gap has declined greatly during past several decades. The earnings gains from a college education have grown since 1980 for both men and women. The explanation is technological change that favors more educated workers, a shift of output toward more education-intensive goods, and growing globalization that apparently added to the demand for more skilled workers. Declining discrimination against women and the shift of output from manufacturing to services benefited women, but whether it especially benefited more educated women is less clear.

Figure 7 plots the college and post-college earnings premiums for full-time, full-year men and women in the United States starting in the 1960s. The premium for women is less representative of all women since it may depend on which married women participate in the labor force. Any bias from this source, however, probably declined over time as a much larger fraction of married women began to work. In any case, there has been little difference in the premiums for men and women since the early1980s. Both premium grew sharply over time, but at about the same rate (for further analysis, see Hubbard (2009)).

The earnings benefits from college depend not only on the college earnings premium, but also on hours worked. Married women still on average work fewer hours per year than men both because married women are more likely to be out of the labor force than married men, and because women work fewer hours than married men do when they are in the labor force (see Figures 8 and 9). While the college wage premium to workers may be the same for men and women, college men are still more likely than college women to reap this benefit.

Finally, the monetary benefits from college are higher when mortality rates during working years are smaller. In this dimension women have an advantage since mortality rates at every age are lower for women than for men, although the effect of these differences on the present value of earnings may not be large since mortality differences becomes important only after about age 50. The expected earnings benefits of college are still lower for women than for men, although this difference narrowed appreciably over time.

3.2 College Education and Mortality

Women have lived longer than men on average ever since deaths during childbirth were reduced to very low levels. Mortality rates of both men and women are affected by education, but the education effects are larger for men. Using OLS regressions of mortality on education, gender, income, and other controls, Sanchez (2009) finds that an additional year of education is associated with a reduction in 11-year mortality for individuals age 51-81 by 0.7 percentage points for males and 0.5

percentage points for females. It appears, too, that this relationship may be causal. Lleras-Muney (2005) finds that OLS and IV estimates of the effect of education on health are not statistically different from each other.

In data on life expectancy at age 25, Meara, Richards, and Cutler (2008) find the same type of education effects on mortality. The authors find that during 1981-88, their earlier time period, the difference in life expectancy between high and low educated white men was 3.6 years, while it was only 1.3 years for white women, even though white women had considerably higher life expectancy than white men at all education levels. In fact, at age 25, low-educated white women could expect to live more than 3.5 years longer than high-educated white men. Ten years later, the effect of education on life expectancy increased compared to the earlier period for both men and women, so that the gap in life expectancy by education widened to 4.4 years for white men and to 2.5 years for white women. The gender difference in the effect of education declined from 2.3 to 1.9 years, but it did not disappear.

Improvements in the probability of surviving to different ages need to be valued by the statistical value of life to get the monetary value of the effect of college education on life expectancy. There is no direct evidence on how the statistical values of life compare for men and women of different education levels.

The increased effect over time of education on life expectancy may be related to the increased effect over time of education on earnings—shown in Figure 7—since persons with higher incomes live longer. However, that does not seem to be a likely explanation for the decline in the gender gap in the effect of education on life expectancy since the relative earnings of highly educated women grew about at the same rate as the relative earnings of highly educated men.

This evidence on the relation between life expectancy and education indicates that the effect of college on this measure of health is more important for men than for women, although these gender differences in the health effects of college education narrowed over time. This narrowing of the gender gap in the effects of college education on mortality rates would increase the incentives for women to go to college relative to the incentives for men. However, since the effect of college on life expectancy is still greater for men, this narrowing of the gender gap would not give women a greater incentive than men to go to college.

3.3 College Education and Marriage

Marriage, especially a stable marriage, tends to raise the utilities of both spouses, which explains why marriage has been such a pervasive institution for thousands of years in different cultures in all parts of the world. Unfortunately, direct evidence on the size of the benefits to men and women from marriage is not available, although there is indirect evidence, and abundant evidence on the propensities of men and women of different education levels to marry and stay married. Figure 10 plots the fractions of men aged 40-44 currently married by education at ten-year intervals between 1967 and 2007, while Figure 11 shows the same data for women.

Figure 10 shows that in each decade, college-educated men are more likely to be married than are men with a high school education. Moreover, while the effect of education on whether males aged 40-44 were currently married was weak through the 1980s, the education-marriage advantage for males got considerably stronger since then. By 2007, the fraction of men aged 40-44 who had college degrees and were married was about fifteen percentage points higher than the fraction of male high school graduates who were married. The gap between men with graduate degrees and high school dropouts was still larger, at twenty percentage points.

The results for women in Figure 11 are even more interesting. While the fraction of women aged 40-44 who were married was always higher for high school graduates than for high school dropouts, a dramatic reversal took place in the marriage market fortunes of women with higher education. Until the 1980s, the fraction married was higher for high school graduates than college graduates and it even was higher for women who were high school *dropouts* than for women with advanced degrees. Yet by the late 1990s this large marital disadvantage for women with graduate degrees had largely disappeared. In 2007, women with graduate degrees were at least as likely to be married as were women with a 4-year college degree, and both groups were considerably more likely to be married than women who graduated high school.

Figures 12 and 13 plot the share of 40- to 44-year-olds who were currently divorced or separated. (The CPS does not provide data on ever-divorced status.) Particularly since 1970 when divorce rates started to grow, currently-divorced rates are smaller for the college educated. This indicates that college-educated men and women are less likely to divorce, or more likely to remarry when divorced, although the later marriages of college-educated men and women also give them less opportunity to run into marital problems that lead to divorce. As with marriage, the effect of college on women's outcomes has changed more dramatically over time, but the effect for women is still no larger than for men: for both sexes the probability of being divorced is about 10 percentage points lower among those with college degrees than those with only high school degrees.

The marital disadvantage to women from going to college in earlier years was changed into a strong advantage in more recent years. The reasons for this turnabout relate to declining fertility, the increased relative earnings of college-educated women, and the growing value to health and other aspects of life of having a greater command of knowledge and information. Declining fertility and growing importance of knowledge and information decreased the role of reproduction in marriage, and increased the significance of companionship. Since college-educated women earn much more, have fewer children, and have a greater command of knowledge than other women, educated women have become much more attractive as spouses than they were in the past.

No evidence is available on the increase in the real full wealth of married men and women due to the productivity of their marriages. However, very rough approximations to the benefits from college education that come through marriage are available from differences in family income by education level. Although the shares of family income that husbands and wives receive (i.e., consume) are not known, the percentage difference in family incomes by education levels for each

gender would equal their percentage increase in their monetary benefits from college if high school and college men, and high school and college women, receive the same shares of their marital incomes. The shares of men and women do not have to be equal for this to be true.

Table 1 presents the percentage differences in average family incomes between married college and high school graduates for regular intervals from 1967-2007. Family incomes rise with education for both men and women, and they are much higher for college graduates than for high school graduates. These differences are substantial—in 2007, about 90 percent—but like the earnings benefits they are not much different for college educated women than college educated men.

TABLE 1:
RATIO OF TOTAL FAMILY INCOME OF MARRIED COLLEGE GRADUATES
TO MARRIED HIGH SCHOOL GRADUATES, BY SEX

	1967	1977	1987	1997	2007
Men	1.518	1.511	1.666	1.832	1.897
Women	1.454	1.473	1.654	1.832	1.932

Source: Analysis of King, et al. (2008).

The improved marriage market for college-educated women increased the incentives for women to go to college. The marriage market for educated men also increased, presumably because of the previously discussed greater earnings and health of college-educated men relative to other men, and the growing emphasis on knowledge and information. Educated men also became more attractive in the marriage market as providers and companions that gave men an additional incentive to go to college. As Figures 10 and 11 show, while the marriage market for college-educated individuals improved, it is not clear that the improvement was greater for women than men. Changes in marriage and divorce rates do not explain why women now are more likely than men to go to college.

3.4 College Education and Children's Human Capital

Numerous studies indicate that the children of parents with a college education are much more likely to go to college, even when family income is held constant (see Haveman and Wolfe (1995)). Several studies show that mothers generally put greater emphasis on their children's education than fathers do (see, e.g., Duflo (2000); Lundberg, Pollack, and Wales (1996)). However, father's education appears to have at least as large an effect on their children's education as does mother's education (see Behrman and Rosenzweig (2002); Plug (2004)).

4. Gender Differences in the Full Cost of College

The total benefits from college are high for both men and women, and they have risen during the past 30 years. While benefits for women appear to have increased

relative to those for men, total college benefits appear to be still lower for women than men. Hence, gender differences in benefits alone cannot explain why a much larger fraction of women than men graduate college not only in the United States, but also in many other countries. The most likely explanation depends on gender differences in the total cost of going to college, especially costs related to performance in school.

The main monetary cost of college is the forgone earnings from being in college rather than working, but gender differences in forgone earnings do not seem able to explain the greater propensity of women than men to go to college in recent years. For if as seems reasonable, forgone earnings are about the same proportion of high school hourly earnings for both men and women, forgone earnings relative to the monetary benefits of college would be about equal for both men and women. The reason is that, as Figure 6 shows, gender difference in the hourly earnings of college graduates relative to high school graduates are minor.

We do not have any evidence on gender differences in either tuition or difficulties in financing a college education; we assume that the tuition and student loans offered to women and men are comparable for men and women of equal abilities. We concentrate our analysis on various other costs of attending college, which depend on a student's cognitive and non-cognitive skills.

Both cognitive and non-cognitive abilities affect the cost of schooling, partly by increasing scholarships and lowering tuition and other fees, but mainly by lowering the psychic or non-monetary costs of schooling. Higher cognitive and non-cognitive abilities make the accumulation of human capital in college "easier," as reflected in higher grades and other measures of school performance. College performance in turn affects how long a student continues in college, including whether they graduate from a four-year college.

Indeed, there is an emerging body of literature supporting the connection between cognitive and non-cognitive skills and measures of school performance such as probability of high school graduation and enrollment in college. See Cunha and Heckman (2008); Cunha and Heckman (2007). These effects of cognitive and non-cognitive abilities on the production of human capital from college imply that persons with greater abilities receive higher net returns from college even when total benefits from college are the same.

Therefore, gender differences in the distributions of cognitive and non-cognitive abilities might be important in explaining gender differences in the propensities to go to and graduate from college. Gender differences in the means of cognitive measures like IQ are minor, but the degree of variability in cognitive abilities appear to be greater among men than women. For example, Bound, Griliches and Hall (1986) report IQ scores from high school intelligence tests for boys and girls. The means for boys and girls are essentially identical (101.4 and 102.3, respectively), but the standard deviation for boys is somewhat higher (15.9 and 15.2, respectively).

However, the main ability differences between men and women are in the non-cognitive arena. Table 2 presents several measures of the mean and variability in

the non-cognitive abilities of boys and girls. They show that girls have both higher average levels and smaller variances of non-cognitive abilities than boys do.[1] Importantly, non-cognitive abilities are at least as important as cognitive abilities in determining academic success and life outcomes. Heckman, Stixrud, and Urzua (2006) find that non-cognitive skills are as important as, if not more important than, cognitive skills in determining many aspects of social and economic success including the probability of being a 4-year-college graduate at age 30.

TABLE 2A:
MEASURES OF NON-COGNITIVE ABILITY, EIGHTH GRADE NELS RESPONDENTS

	Means		Standard Deviations	
	Boys	**Girls**	**Boys**	**Girls**
Positive Measures				
Middle School Grades	2.932	3.065	0.741	0.704
Hours Worked on Homework per Week	5.877	6.208	4.962	4.890
Negative Measures				
Behavior Problem	0.405	0.195	n/a	n/a
Behavior Composite Score	0.296	–0.435	1.801	1.250
Repeated Grade in Elementary School	0.175	0.115	n/a	n/a

Source: Jacob (2002).

Note: "Behavior Problem" and "Repeated Grade in Elementary School" are indicator variables, and thus standard deviations are not reported here.

Non-cognitive abilities affect grades and test scores by affecting how much attention students pay to instruction from their teachers, how organized they are in doing homework and preparing for exams, whether they get disciplined for inappropriate behavior at school, and in various other ways. Therefore, differences in average non-cognitive abilities of males and females would imply that average grades will be higher for women than for men. Figure 14, which plots the mean grade point averages of boys and girls who graduated from high school, shows that girls have higher average grades than boys throughout college. The mean first-year undergraduate GPA for women is 3.02 and for men is 2.84 (Beginning Postsecondary Students Longitudinal Study; see NCES (2008b)). The mean cumulative undergraduate GPA for women is 2.72 and for men is 2.63 (High School & Beyond; see NCES (2008b)).

Non-cognitive abilities affect performance on achievement tests as well. Interestingly, however, the differing means in the measures of non-cognitive ability

[1] While it seems clear these differences exist, we are not in a position to speculate as to their cause or causes.

for boys and girls do not consistently show up in achievement test scores for boys and girls. Figure 18 shows that differences between averages scores of boys and girls on several subjects in the PISA tests administered in 2003 to teenagers in 41 countries display no clear consistent pattern across countries. Likewise, Kenney-Benson, et al. (2006) find no significant difference in achievement test scores for boys and girls in their sample of Illinois middle-school students. Rodgers and Spriggs (1996) examine the AFTQ scores of black, white, and Hispanic men and women and find virtually no difference in average scores between males and females in any group. These results on grades and test scores may indicate that grades involve greater non-cognitive inputs than do test scores.

Nonetheless, the consistent pattern of males having higher variability in cognitive and especially non-cognitive skill measures is replicated in both grades and achievement test scores. Figures 15-17 compare the distributions of GPAs of American high school students and college students. Table 3 reports generally higher variances among boys than girls across a range of achievement test and aptitude test scores. Most recently, Conger and Long (2010) examine a sample of 16 universities in Florida and Texas and find that women complete an average of 6.6 more credit hours than men by their third year, earn GPAs 0.2 higher than men on average, and 79% of women reach the 6th semester compared to only 74% of men.

TABLE 2B:
MEASURES OF NON-COGNITIVE ABILITY, FIFTH AND SEVENTH GRADERS

	Means		**Standard Deviations**	
	Boys	**Girls**	**Boys**	**Girls**
Positive Measures				
Grades, 5th Grade	8.51	8.88	2.03	1.90
Grades, 7th Grade	8.47	9.49	2.97	2.72
Achievement Goals, 5th Grade	–0.28	0.25	1.58	1.31
Achievement Goals, 7th Grade	–0.20	0.23	1.24	1.30
Learning Strategies, 5th Grade	3.69	3.99	0.76	0.62
Learning Strategies, 7th Grade	3.18	3.53	0.86	0.67
Negative Measures				
Disruptive Behavior, 5th Grade	1.98	1.40	0.99	0.56
Disruptive Behavior, 7th Grade	2.41	1.50	1.20	0.68

Source: Kenney-Benson, et al. (2002).

Note: All differences in means are significant at the 5% level.

TABLE 3:
VARIANCE RATIOS (VRS) OF MALES' AND FEMALES' PERFORMANCE ON VARIOUS ACHIEVEMENT AND APTITUDE TESTS

Test	VR	Test	VR	Test	VR
PSAT		**WAIS/WAIS-R**		**DAT**	
Verbal	1.05	Information	1.16	Numerical Ability	1.11
Mathematics	1.24	Digit Span	1.11	Mechanical Reasoning	1.28
SAT		Vocabulary	1.06	Space Relations	1.21
Verbal	1.05	Arithmetic	1.18	Spelling	1.12
Mathematics	1.20	Comprehension	1.02	Verbal Reasoning	0.96
CAT		Similarities	1.04	Abstract Reasoning	1.01
Vocabulary	1.27	Picture Completion	1.08	Language	0.99
Reading Comprehension	1.34	Picture Arrangement	1.07	Clerical Speed and Accuracy	0.94
Language	1.18	Block Design	1.12		
Spelling	1.30	Object Assembly	1.03		
Arithmetic	1.34	Digit Symbol	0.91		

Source: Feingold (1992). See also Kenney-Benson, et al. (2006) and Rodgers and Spriggs (1996).

Note: VRs above 1.00 indicate boys' performance was more variable than girls' performance, and VRs less than 1.00 indicate that girls varied more than boys. All VRs reported are grand medians across sampled grade levels and test years.
PSAT = Preliminary Scholastic Aptitude Test, SAT = Scholastic Aptitude Test, CAT = California Achievement Tests, WAIS = Wechsler Adult Intelligence Scale, WAIS-R = Wechsler Adult Intelligence Scale-Revised, DAT = Differential Aptitude Tests.

The picture is similar internationally, too. Figure 19 shows that the standard deviations are almost uniformly smaller for girls in the international PISA tests for teenagers, across all 41 countries and 4 subject areas.

These differences between men and women in measures of non-cognitive ability and performance in grade school appear to explain much of the growing female advantage in higher education. Golden, Katz, and Kuziemko (2006, Tables 1 and 2) show that part, perhaps a large part, of the improvement in female college completion rates relative to male completion rates are due to gender differences in math and reading scores, and to rank in high school class. They also find that females from all socioeconomic classes are now much more likely than males to graduate from college (also see Jacob, 2002).

Even though total benefits from college are no higher for females than males, and very probably are lower, the net returns might be higher for the average female than the average male since, as we have indicated, the full cost of attending college are likely to be lower for the average female. Although non-cognitive skills and grades in school were higher for females than males in the past as well as in more recent years, women used to greatly lag men in going to college because their total benefits from college were then much lower than were college benefits for men.

5. Equilibrium Returns and Number of Men and Women Going to College

However, to better understand why women are now much more likely to graduate from college than men, college decisions of individual men and women need to be placed within the context of market equilibrium for college graduates. To do this, we assume that the economy's demand for the effective number of college graduates is negatively related to the hourly earnings of college graduates relative to high school graduates. Effective number of graduates equals the number of male graduates plus the equivalent number of female graduates, where female graduates would be converted into male graduates at the ratio of their average hourly earnings to that of males. The demand equation is

$$11)\ C = C_m + aC_f = D\left(R = \frac{w_c}{w_h}, P\right),$$

where C is the effective number of college graduates demanded, a is the conversion rate of female graduates (C_f) into male graduates (C_m), and P represent technological progress and other forces that increase demand for college graduates. Demand is negatively related to the wage ratio, R.

The supply of both male and female college graduates is positively related to the common benefit from going to college rather than stopping after high school. This is given by $R=w_c/w_h$, so that

$$12)\ C_m = S_m(R, N_m, A_{cm}, A_{nm})$$

$$13)\ Cf = S_f\left(R, N_f, A_{cf}, A_{nf}\right)$$

Where N_m and N_f refer to the non-monetary returns from college to men and women, and A_{cm}, A_{nm}, $A_{cf.}$, and A_{nf} refer to the distributions of cognitive and non-cognitive abilities among men and women.

Equilibrium in the market for college graduates requires aggregate demand to equal aggregate supply of effective college graduates, as in

$$14)\ D\left(R = \frac{w_c}{w_h}, P\right) = S_m(R, N_m, A_{cm}, A_{nm}) + a\, S_f\left(R, N_f, A_{cf}, A_{nf}\right) = S$$

Given P, the N's ,and the A's, equality between D and S determines the equilibrium monetary benefit from going to college, R, and the number of persons of each gender that go to college, C_m and C_f. Figure 20 graphs for the period before the mid-1970s the equilibrium number of male and female college graduates and the equilibrium return, R.

At this equilibrium return to both men and women, the number of women going to college is significantly below that of men: $C_m > C_f$. Even though non-cognitive abilities have for at least the past 50 years been on the average higher for women than men, that was more than offset in earlier decades by sufficiently greater non-monetary returns to college men compared to college women in the form of greater marital propensities, greater labor force participation, greater health benefits, and perhaps greater other benefits as well.

During the past 30 years monetary returns to college have risen substantially in the US and many other countries. Since the fraction of high school graduates who go to college has also risen, quite sharply in many countries, the rise in returns combined with increased supply would indicate that the demand for college graduates shifted outward. Presumably, the reason for this shift is technological change that favored college graduates, changes in output mix toward college-intensive industries, globalization, and other shifts in favor of college graduates (see Katz and Murphy (1992)).

If the supply curves of men and women to college were stable, the increase in demand for college graduates would increase the number of both sexes that go to college by increasing the return from college. Given the increase in returns from college, the percent increase in college attendance of each gender would be positively related to the supply elasticity of that gender. These supply elasticities are negatively related to the degree of heterogeneity among men and women in abilities, both cognitive and non-cognitive, and in non-monetary returns. The supply curve of each gender would be the cumulative distribution of the benefits, net of full costs, for all members of each gender. Those persons with low costs of attending college would be willing to got to college even with low monetary benefits, while those with the highest costs would require high monetary benefits to induce them to go to college.

The evidence we presented earlier indicates that the variability in non-cognitive abilities, and perhaps also in cognitive abilities, is greater for men than for women. This implies that the elasticity of supply to college is greater for women than for men, so that the increased demand for college graduates would induce a greater

increase in the number of women going to college than in the number of men going. The greater response of women than men to the upward shift in demand could even imply that the number of women going to college would overtake that of men. This possibility is illustrated in Figure 21, where demand shifts from D to D', the wage gain increases from R to R', and the number of men going to college increases from C_m to C'_m, while the number of women going to college increases by much more, from C_f to $C'_f > C'_m$.

However, supply curves to college did not remain constant as monetary returns increased since various non-monetary benefits of a college education also increased, such as the effects of going to college on the propensity to marry and stay married. Moreover, as argued earlier, the gap between the non-monetary benefits from college of men and women narrowed, as college women sharply increased their labor force participation and their propensity to marry, and perhaps also their other non-monetary benefits of college. Even though men on average appear to still get larger non-monetary benefits from college than women do, the substantial narrowing in the gender non-monetary benefit gap could have shifted the supply curve of women to the right of that of men. The reason is that the average level of non-cognitive skills is greater for women than for men, so that the average full cost of going to college would be smaller for women.

This is shown in figure 22, where the supply curve of men shifts over time from S_m to S'_m, while the supply of women shifts from S_f, which is to the left of S_m, to S'_f, which is to the right of S'_m. As the figure shows, even if demand did not shift outward, these shifts in supply would have induced the fraction of women going to college to surpass the fraction of men going. However, given that the elasticity of the supply of women going to college also exceeds that of men, the outward shift in demand would produce an even greater positive gap between the proportion of women and men who go to college.

The fraction of women with a college education exceeds the fraction of college men not only in most rich countries, but also in many developing countries, such as Brazil and Iran. In developing countries, non-monetary returns in the form of labor force participation, propensity to marry, and in other dimensions, appear to still be much lower for college women than men. Since monetary benefits from college have risen in many developing countries as well as developed countries, including Brazil, China, and India, this evidence suggests that gender differences in elasticities of supply are important contributors to why the propensity to go to college is now greater for women than for men in many developing as well as developed countries.

6. Conclusion

We showed that gender differences in the earnings, health, marriage, and other returns from college greatly narrowed after the 1970s. Therefore, even if the means and distributions of the costs of attending college had been the same for males and females, the male advantage in college attendance would have narrowed considerably over time. However, if costs were the same, gender differences in college attendance would not have changed in so many countries in favor of females since their returns from college, both monetary and non-monetary, are still generally

lower, or at least no higher, than those of males. This reversal in gender college attendance occurred presumably because females have an advantage on the full cost side of attending college.

Differences in gender means and distributions of abilities, especially non-cognitive abilities, affect the supply of women compared to men to college since the full cost of college is lower for abler persons. We show that the average non-cognitive abilities of women are higher than the average for men, as measured by average grades in school and standardized test scores. We also show that the inequality in non-cognitive abilities is lower for women, as measured by the variances in these grades and test scores.

Lower inequality of non-cognitive abilities among women than men imply that elasticities of supply to college would be greater for women than men since heterogeneity in costs of college attendance would be lower for women. Greater average non-cognitive abilities of women than men implies that the supply of women to college would be greater than that of men when their benefits were the same. The gender differences in mean abilities implies that as total benefits from college narrowed over time between men and women, the lower average full cost of women could help explain why women overtook men in their likelihood of graduating from college. The gender differences in supply elasticities implies that the increased demand for college graduates that occurred in most countries during past 30 years would have increased the supply of women to college by more than the supply of men. This too could have caused women's college attendance to surpass that of men.

References

Behrman, Jere R., and Mark R. Rosenzweig. 2002. "Does Increasing Women's Schooling Raise the Schooling of the Next Generation?" *AER* 92(1):323-334.

Bound, John, Zvi Griliches, and Bronwyn H. Hall. 1986. "Wages, Schooling and IQ of Brothers and Sisters: Do the Family Factors Differ?" *Int'l Econ. Rev.* 27(1):77-105.

Chiappori, Pierre-Andre, Murat Iyigun, and Yoram Weiss. 2009. "Investment in Schooling and the Marriage Market." *AER* (forthcoming).

Conger, Dylan, and Mark C. Long. 2010. "Why are Men Falling Behind? Explanations for the Gender Gap in College Outcomes." *ANNALS of the American Academy of Political and Social Science* (forthcoming).

Cunha, Flavio, and James J. Heckman. 2007. "The Technology of Skill Formation." *AER* 97(2):31-47.

Cunha, Flavio, and James J. Heckman. 2008. "Formulating, Identifying and Estimating the Technology of Cognitive and Noncognitive Skill Formation." *Journal of Human Resources* 43(4):738-782.

Duflo, Esther. 2000. "Child Health and Household Resources in South Africa: Evidence from the Old Age Pension Program." *AER* 90(2):393-398.

Feingold, Alan. 1992. "Sex Differences in Variability in Intellectual Abilities: A New Look at an Old Controversy." *Review of Educational Research* 62(1):61-84.

Goldin, Claudia, and Lawrence F. Katz. 2008. *The Race between Education and Technology*. Cambridge and London: Harvard University Press, Belknap Press.

Haveman, Robert, and Barbara Wolfe. 1995. "The Determinants of Children's Attainments: A Review of Methods and Findings." *JEL* 33(4):1829-1878.

Heckman, James J., Jora Stixrud, and Sergio Urzua. 2006. "The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior." *JLE* 24(3):411-82.

Heston, Alan, Robert Summers, and Bettina Aten. 2006. Penn World Table Version 6.2. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania. Online at http://pwt.econ.upenn.edu.

Katz, Lawrence F., and Kevin M. Murphy. 1992. "Changes in Relative Wages, 1963-1987: Supply and Demand Factors." *QJE* 107(1):35-78.

Kenney-Benson, Gwen A., Helen Patrick, Eva M. Pomerantz, and Allison M. Ryan. 2006. "Sex Differences in Math Performance: The Role of Children's Approach to Schoolwork." *Developmental Psychology* 42(1):11-26.

King, Miriam, Steven Ruggles, Trent Alexander, Donna Leicach, and Matthew Sobek. 2008. Integrated Public Use Microdata Series, Current Population Survey: Version 2.0. Minneapolis, MN: Minnesota Population Center. Online at http://cps.ipums.org/cps/.

Lundberg, Shelly J., Robert A. Pollak, and Terence J. Wales. 1997. "Do Husbands and Wives Pool Their Resources? Evidence from the United Kingdom Child Benefit." *JHR* 32(3):463-480.

Lutz, Wolfgang, Anne Goujon, Samir K.C., and Warren Sanderson. 2007. "Reconstruction of populations by age, sex and level of educational attainment for 120 countries for 1970-2000." *Vienna Yearbook of Population Research* 193-235. (Data online at http://www.iiasa.ac.at/Research/POP/edu07/.)

K.C., Samir, Bilal Barakat, Anne Goujon, Vegard Skirbekk, and Wolfgang Lutz. 2008. "Projection of Populations by Level of Educational Attainment, Age and Sex for 120 Countries for 2005-2050." *IIASA Interim Report IR-08-038* 1-56. (Data online at http://www.iiasa.ac.at/Research/POP/Edu07FP/.)

Lleras-Muney, Adriana. 2005. "The Relationship Between Education and Adult Mortality in the United States." *Rev Econ Stud* 72:189-221.

Meara, Richards, and Cutler. 2008. "The Gap Gets Bigger: Changes In Mortality And Life Expectancy, By Education, 1981–2000." *Health Affairs* 27(2):350-360.

National Center for Education Statistics (NCES). 2008a. *Digest of Education Statistics* Table 268. Washington, DC: United States Dept. of Education. Online at http://nces.ed.gov/programs/digest/.

NCES. 2008b. *Integrated Postsecondary Education Data System (IPEDS), NSF Institutions Set*. Washington, DC: United States Dept. of Education. Online at http://caspar.nsf.gov.

NCES. 2008c. *Data Analysis System (DAS) Online 2.0*. Washington, DC: United States Dept. of Education. Online at http://nces.ed.gov/dasol/.

NCES. 2009. *High School Transcript Study (HSTS) 1990-2005*. Washington, DC: United States Dept. of Education. Online at http://nces.ed.gov/nationsreportcard/hsts/.

Organisation for Economic Cooperation and Development (OECD). 2005. *Programme for International Student Assessment (PISA) 2003*. Dataset, Guide, Technical Guide, and Student Questionnaire Codebook. Online at http://pisa2003.acer.edu.au/index.php.

OECD. 2008. *Education at a Glance 2008: OECD Indicators*. Online at www.oecd.org/education/database.

Plug, Erik. 2004. "Estimating the Effect of Mother's Schooling on Children's Schooling Using a Sample of Adoptees." *AER* 94(1):358-368.

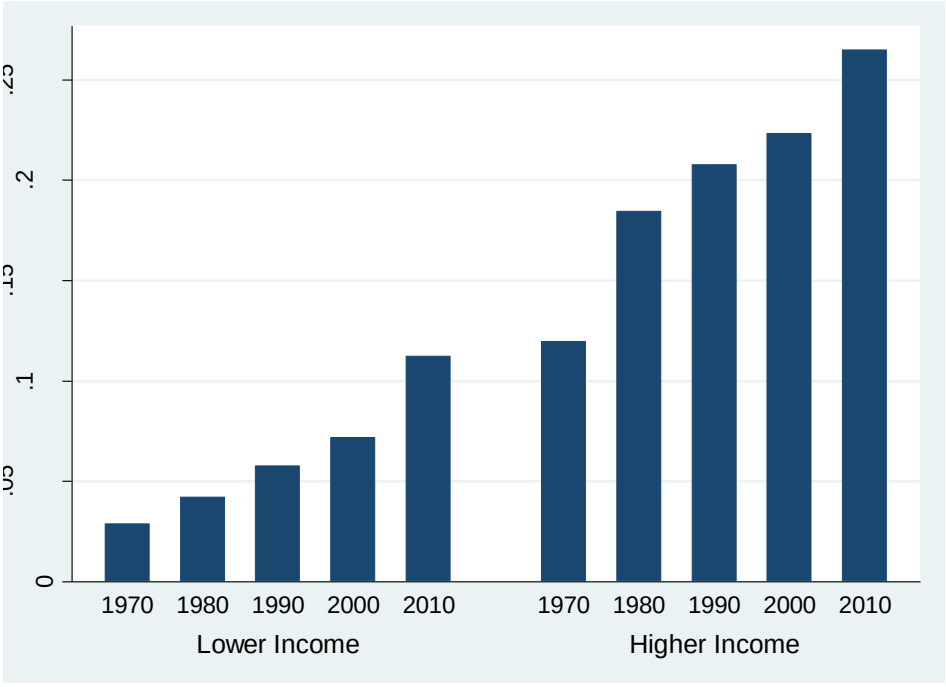
Rodgers, William M., and William E. Spriggs. 1996. "What does the AFQT really measure: Race, wages, schooling, and the AFQT score." *Rev. of Black Pol. Econ.* 24(4):13-46.

Sanchez, Yuri. 2009. "The Longevity Gains of Education." Unpublished.

World Bank. 2008. *World Development Indicators Online*. Online at http://www.worldbank.org/.

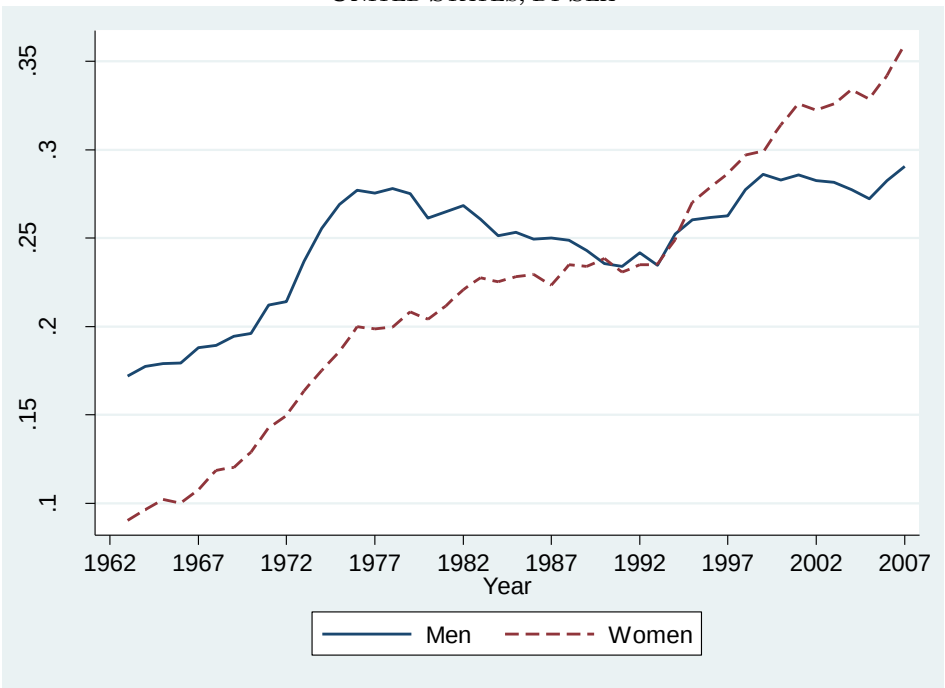
Figures

FIGURE 1: FRACTION OF 30- TO 34-YEAR-OLDS WITH COLLEGE EDUCATION, COUNTRIES ABOVE AND BELOW MEDIAN PER CAPITA GDP



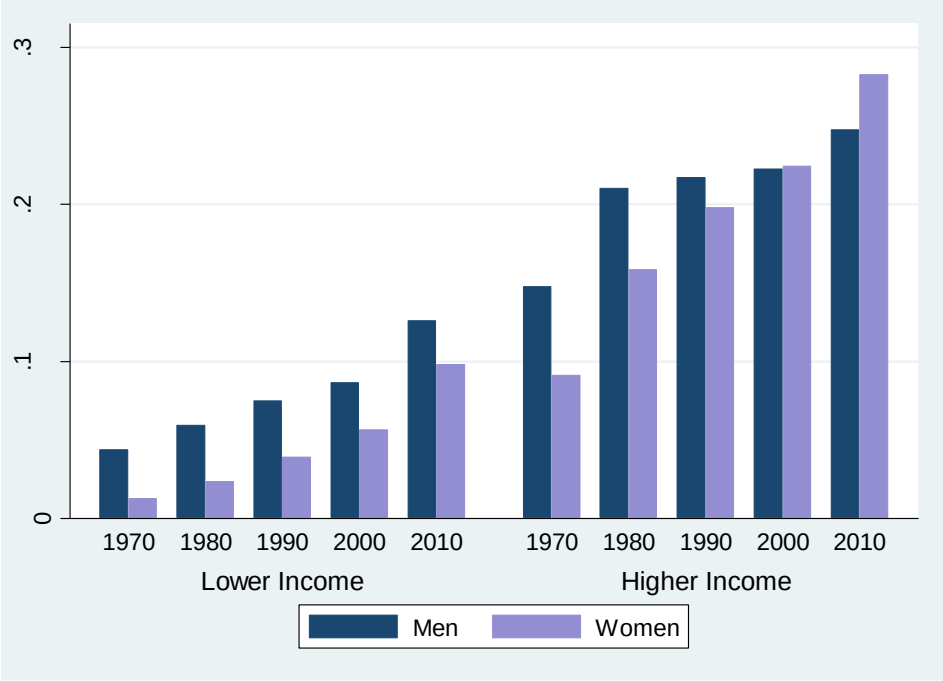
Source: Analysis of K.C., et al. (2008), Lutz, et al. (2008), World Bank (2008), and Heston, et al. (2006). See Data Appendix.

FIGURE 2: FRACTION OF 30- TO 34-YEAR-OLDS WITH COLLEGE EDUCATION, UNITED STATES, BY SEX



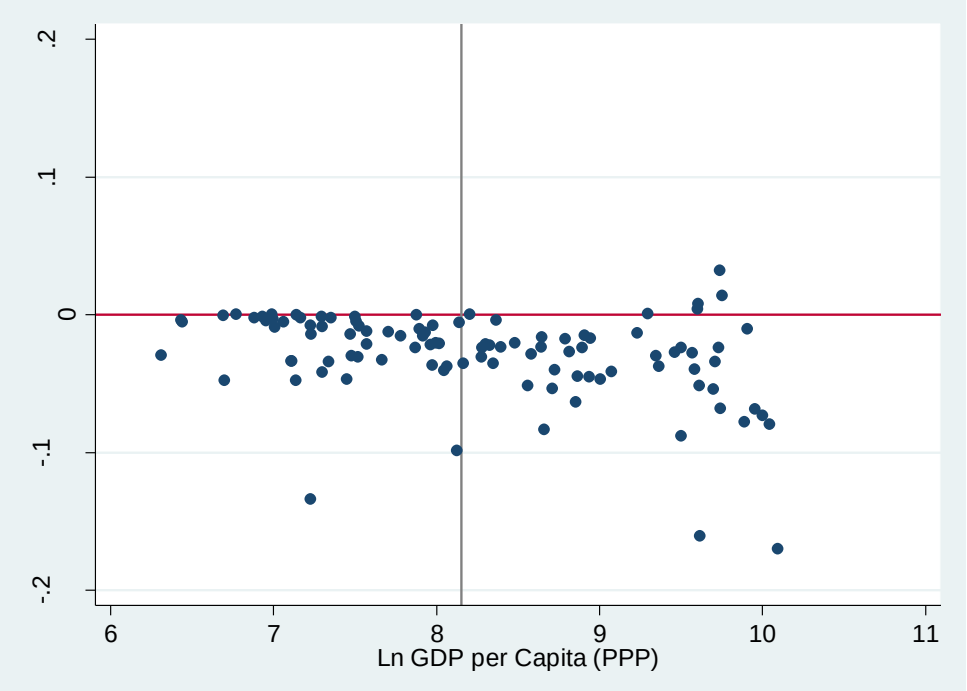
Source: Analysis of King, et al. (2008). See Data Appendix.

FIGURE 3: FRACTION OF 30- TO 34-YEAR-OLDS WITH COLLEGE EDUCATION, COUNTRIES ABOVE MEDIAN PER CAPITA GDP AND BELOW PER CAPITA GDP, BY SEX



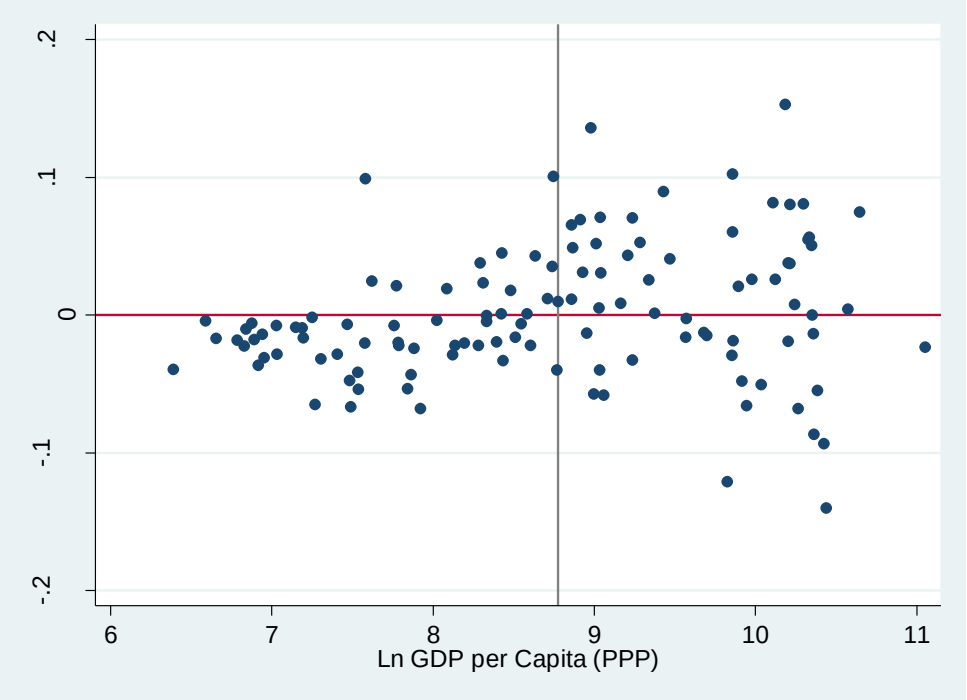
Source: See Figure 1.

FIGURE 4: GENDER DIFFERENCE AMONG 30- TO 34-YEAR-OLDS IN COLLEGE EDUCATION ATTAINMENT, BY PER CAPITA GDP, 1970



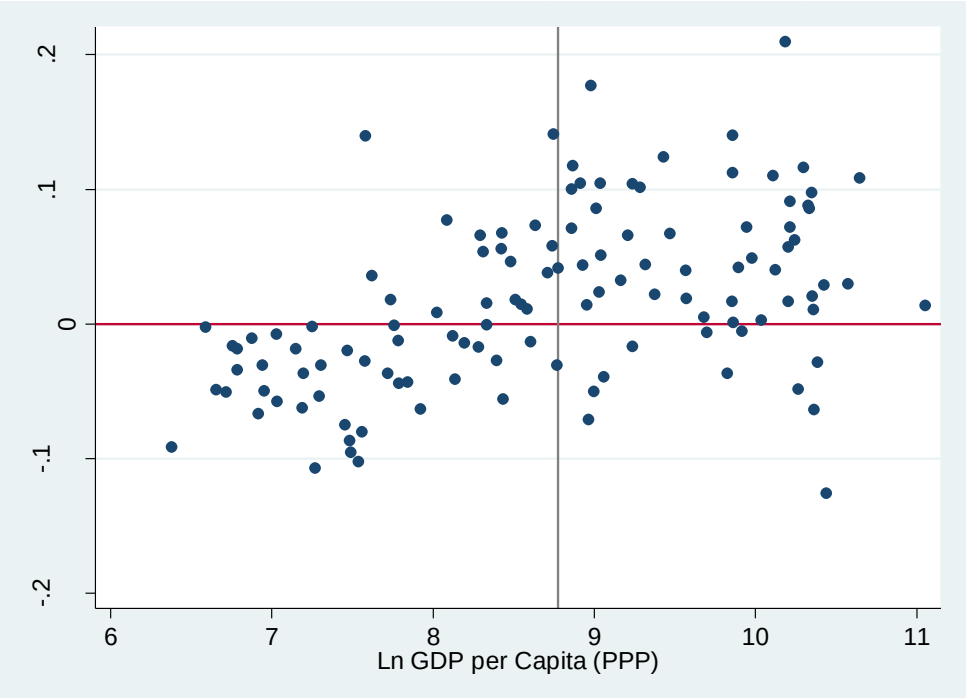
Source: See Figure 1. *Note:* Vertical line represents median log per capita GDP.

FIGURE 5: GENDER DIFFERENCE AMONG 30- TO 34-YEAR-OLDS IN COLLEGE EDUCATION ATTAINMENT, BY PER CAPITA GDP, 2000



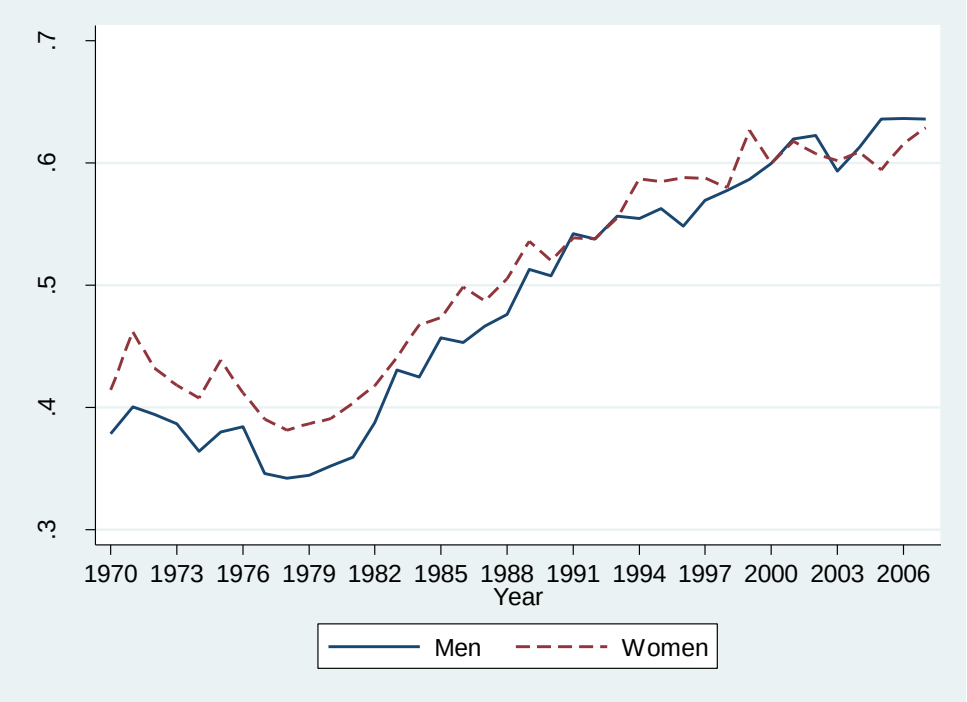
Source: See Figure 1. *Note:* Vertical line represents median log per capita GDP.

FIGURE 6: PROJECTED GENDER DIFFERENCE AMONG 30- TO 34-YEAR-OLDS IN COLLEGE EDUCATION ATTAINMENT, BY PER CAPITA GDP, 2010



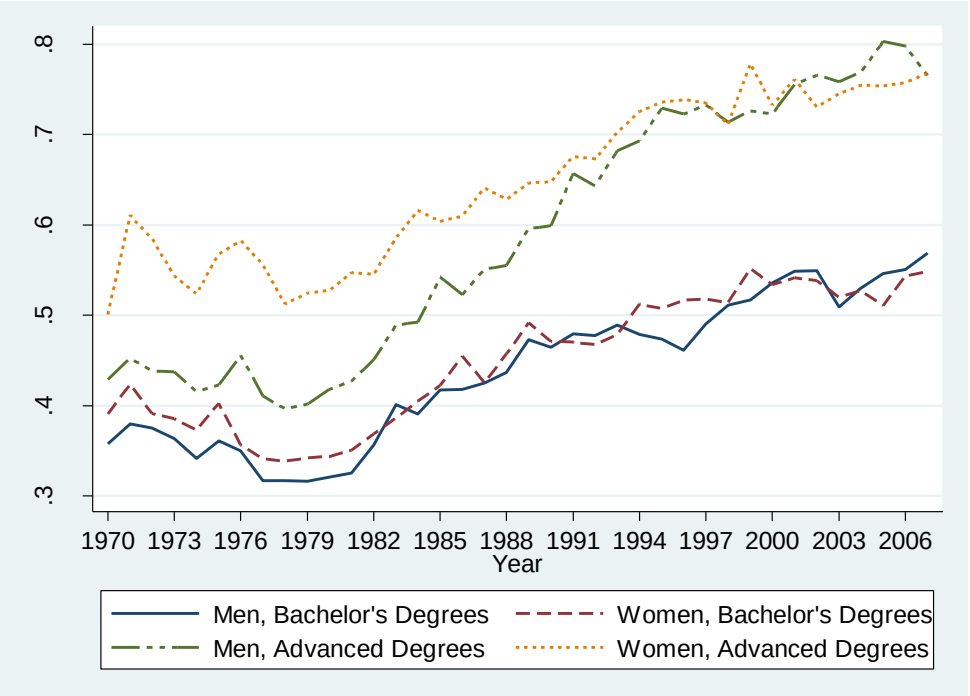
Source: See Figure 1. *Note:* Vertical line represents median log per capita GDP (2000).

FIGURE 7A: COLLEGE WAGE PREMIUMS IN THE UNITED STATES, BY SEX



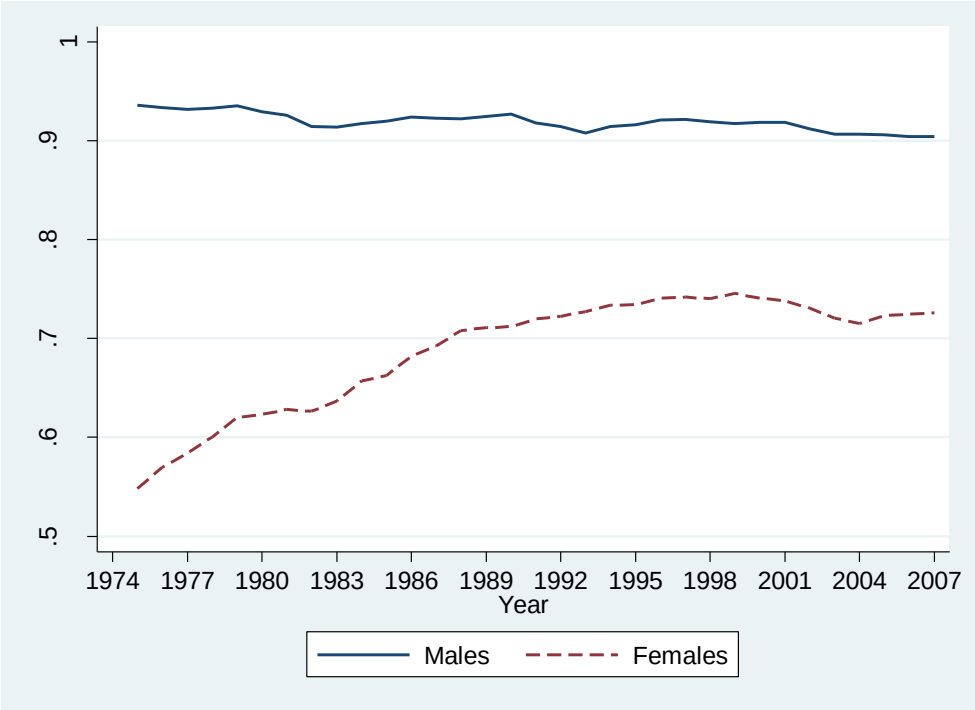
Source: See Figure 2.

FIGURE 7B: BACHELOR'S DEGREE AND ADVANCED DEGREE WAGE PREMIUMS IN THE UNITED STATES, BY SEX



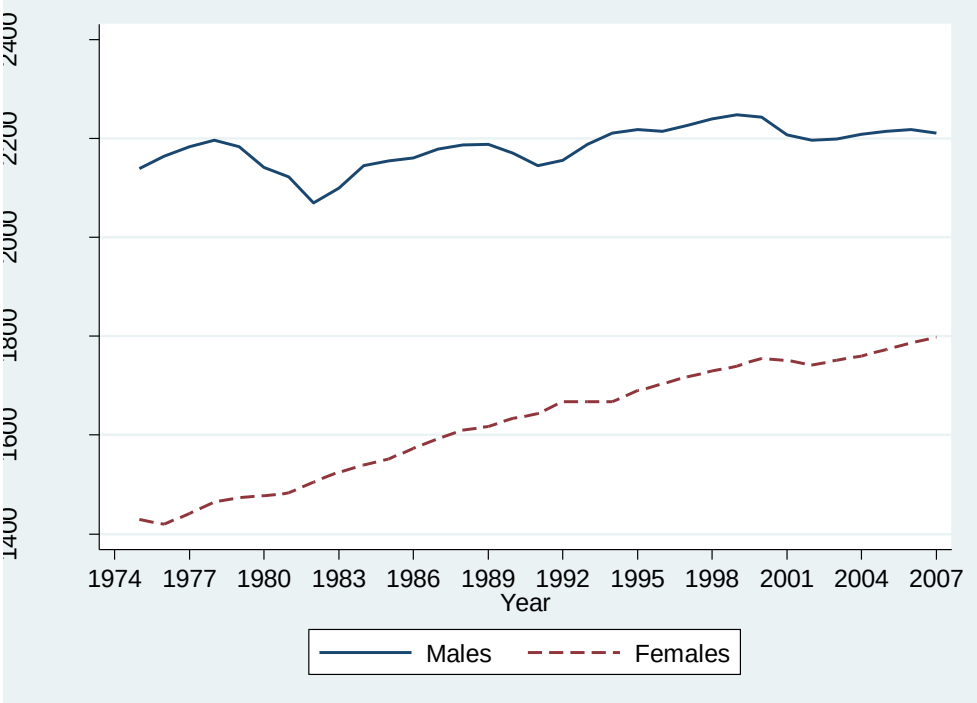
Source: See Figure 2.

FIGURE 8: LABOR FORCE PARTICIPATION OF MARRIED MEN AND WOMEN IN THE UNITED STATES



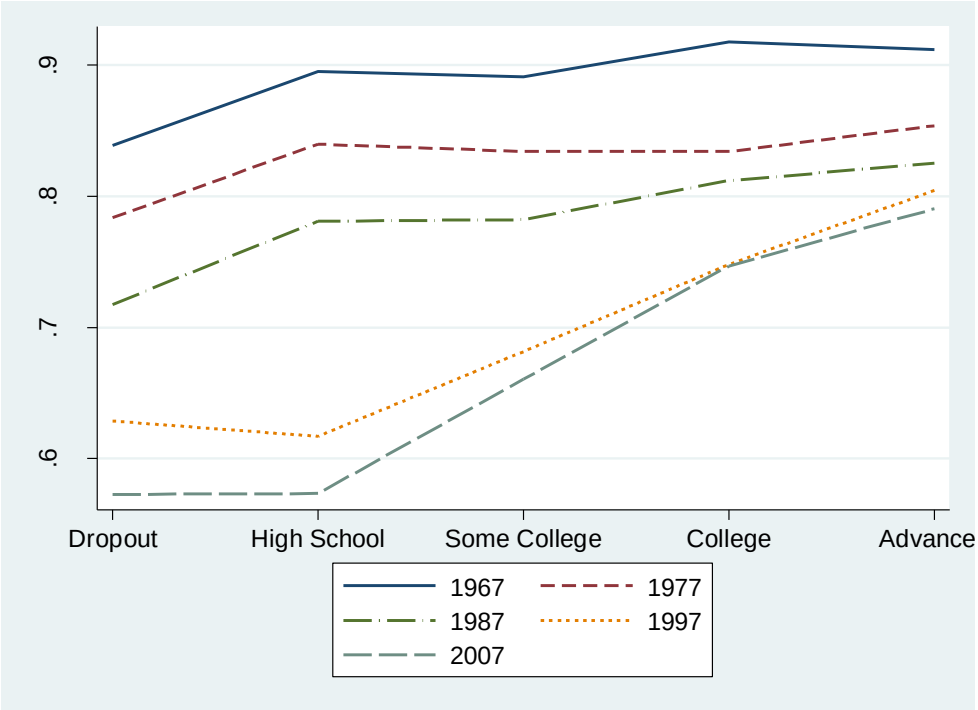
Source: See Figure 2.

FIGURE 9: AVERAGE HOURS WORKERS AMONG MARRIED, WORKING MEN AND WOMEN IN THE UNITED STATES



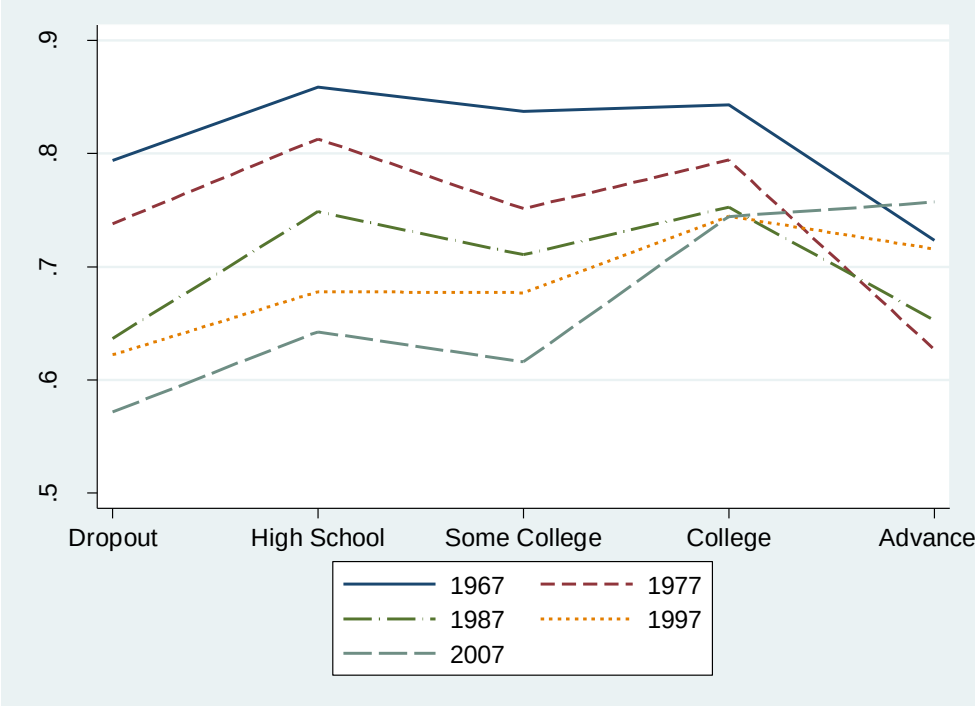
Source: See Figure 2.

FIGURE 10: FRACTION OF MEN AGE 40-44 CURRENTLY MARRIED IN THE UNITED STATES, 1967-2007



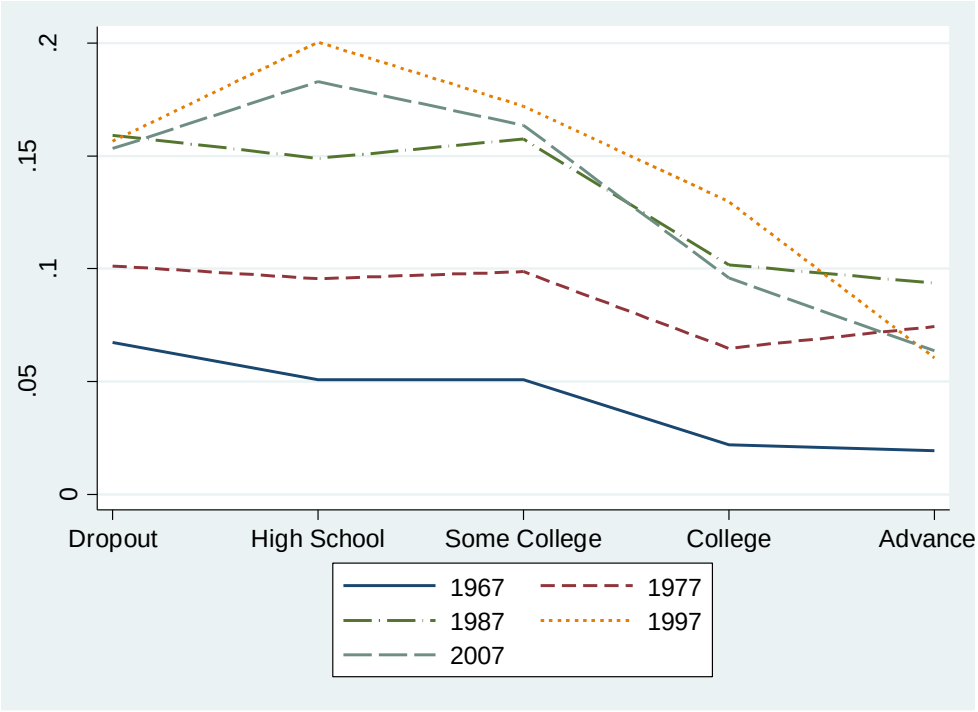
Source: See Figure 2.

FIGURE 11: FRACTION OF WOMEN AGE 40-44 CURRENTLY MARRIED IN UNITED STATES, 1967-2007



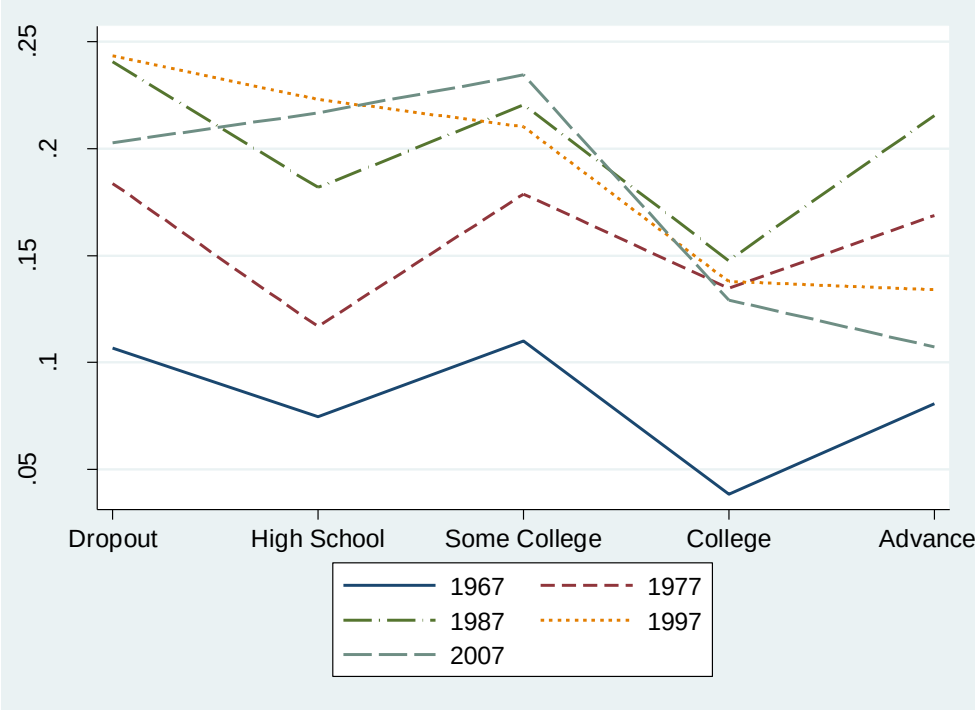
Source: See Figure 2.

FIGURE 12: FRACTION OF MEN AGE 40-44 CURRENTLY DIVORCED OR SEPARATED IN THE UNITED STATES, 1967-2007



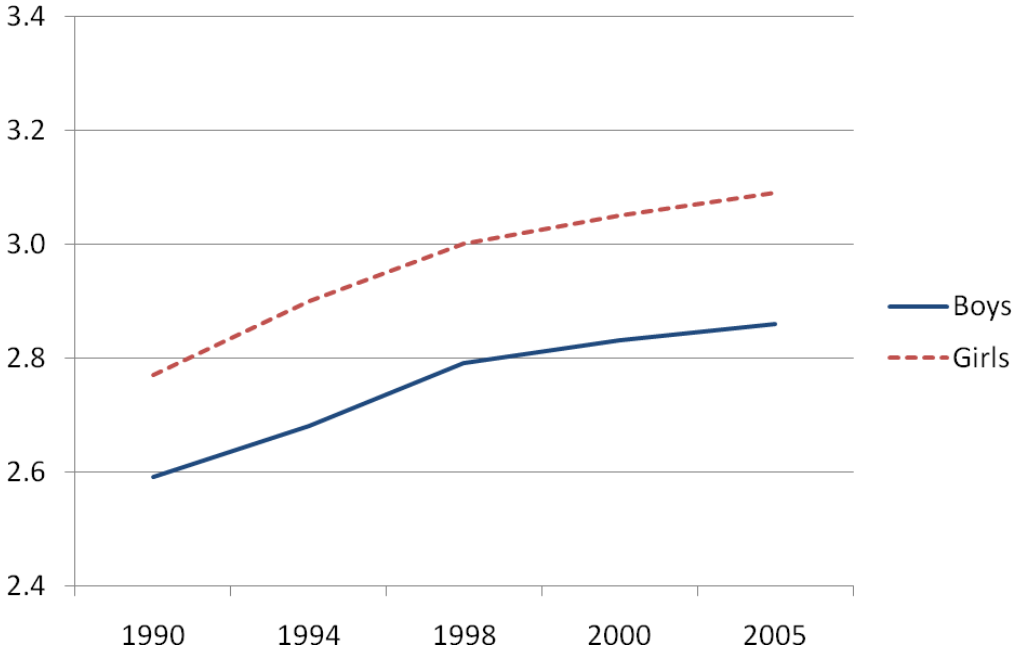
Source: See Figure 2.

FIGURE 13: FRACTION OF WOMEN AGE 40-44 CURRENTLY DIVORCED OR SEPARATED IN THE UNITED STATES, 1967-2007



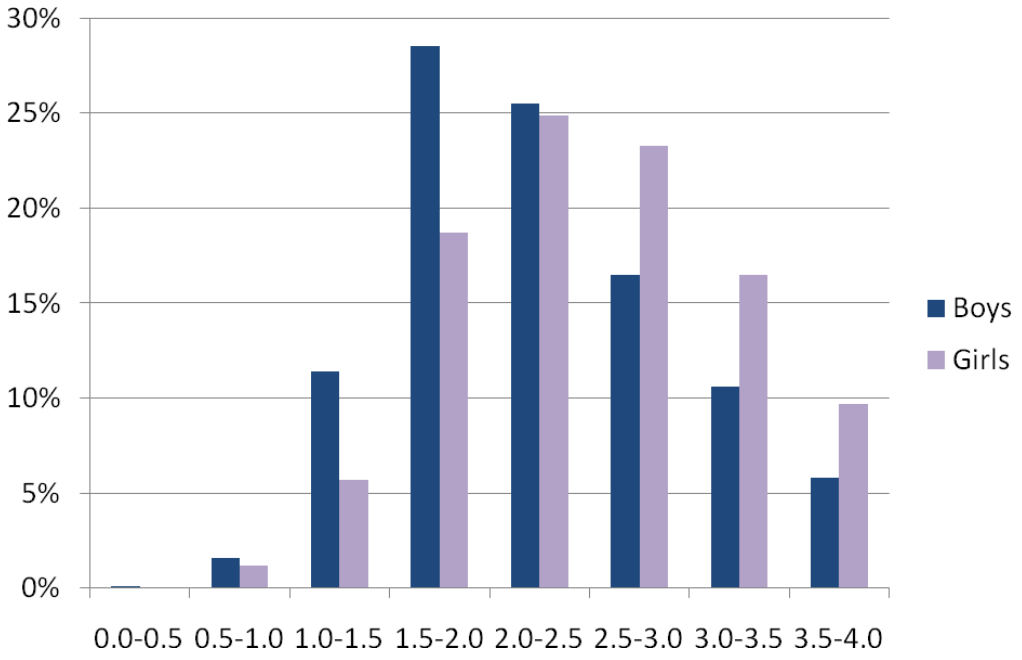
Source: See Figure 2.

FIGURE 14: MEAN GPA OF HIGH SCHOOL GRADUATES, HIGH SCHOOL TRANSCRIPT STUDIES



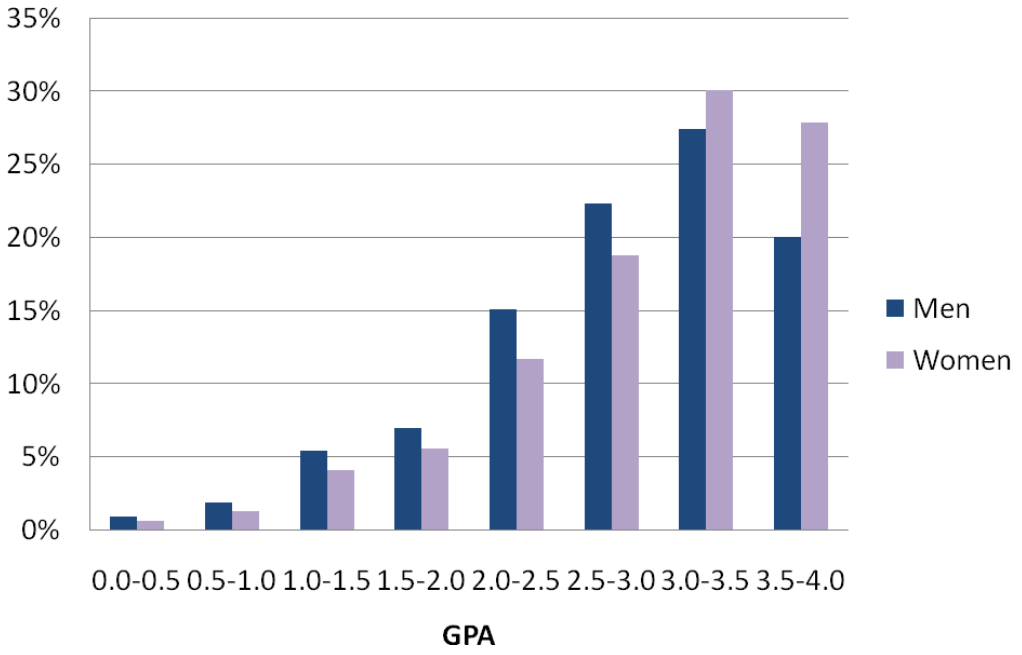
Source: NCES (2009).

FIGURE 15: DISTRIBUTION OF GPA IN ACADEMIC COURSES, 1992 NATIONAL EDUCATION LONGITUDINAL STUDY OF 1988



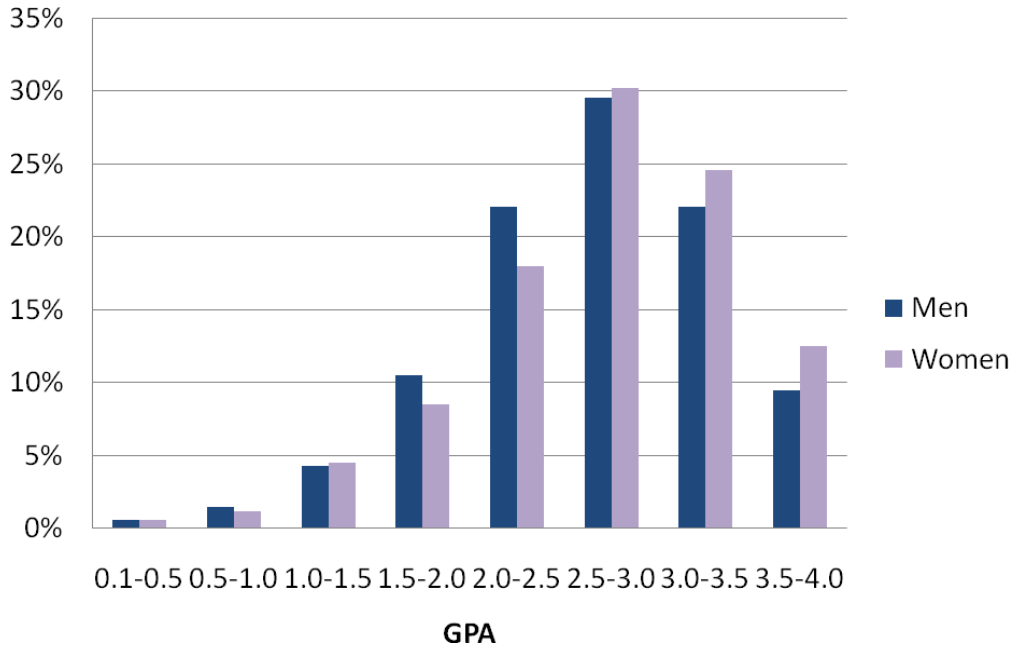
Source: NCES (2009).

FIGURE 16: DISTRIBUTION OF FIRST-YEAR UNDERGRADUATE GPA, BEGINNING POSTSECONDARY STUDENTS LONGITUDINAL STUDY



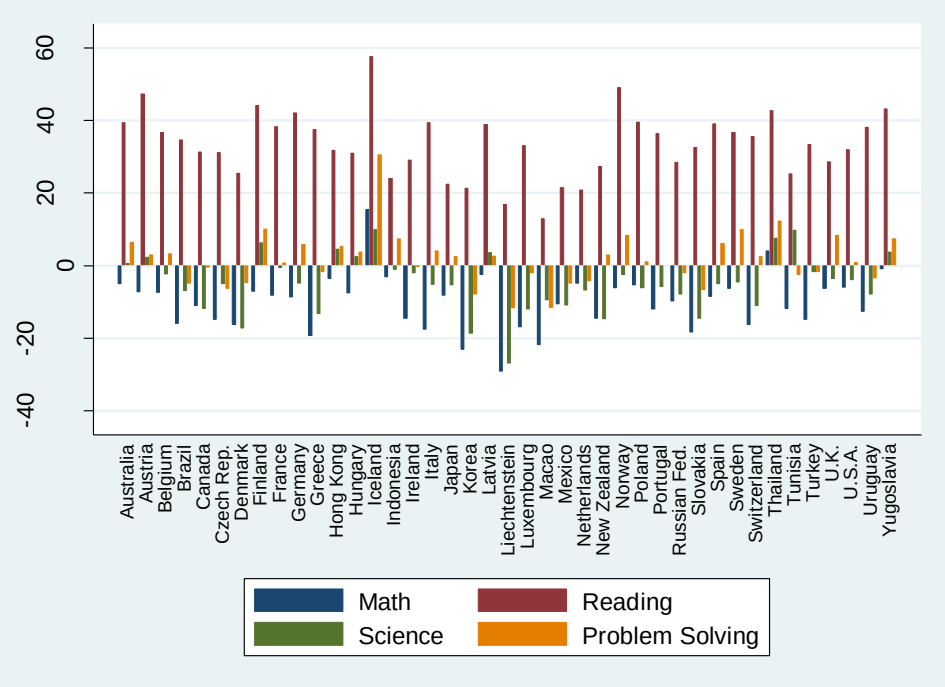
Source: NCES (2008b).

FIGURE 17: DISTRIBUTION OF CUMULATIVE UNDERGRADUATE GPA, HIGH SCHOOL & BEYOND



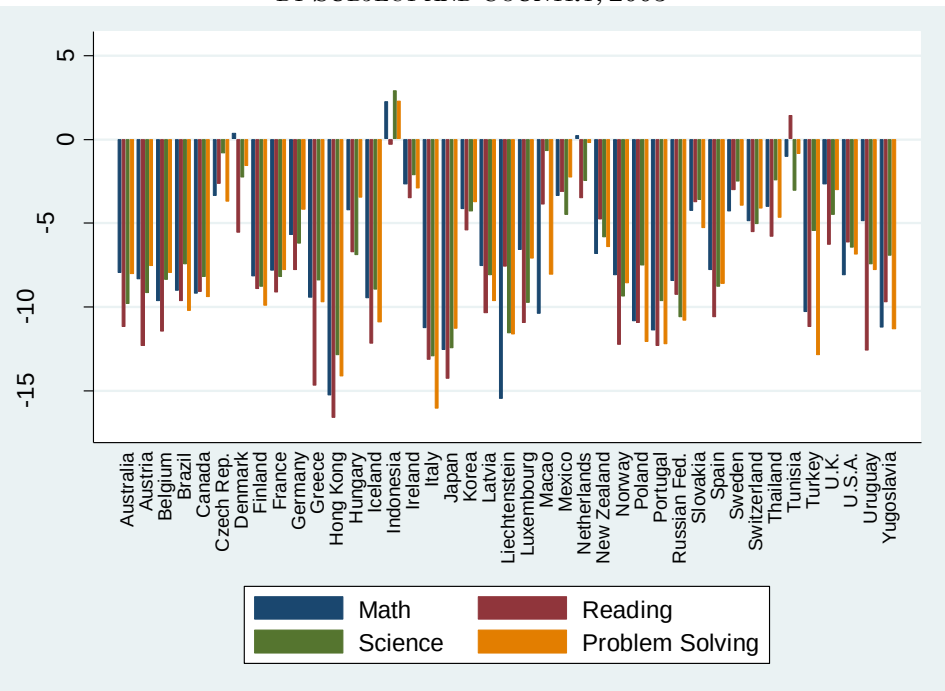
Source: NCES (2008b).

FIGURE 18: FEMALE – MALE DIFFERENCE IN MEAN PISA SCORES BY SUBJECT AND COUNTRY, 2003



Source: Analysis of OECD (2005).

FIGURE 19: FEMALE – MALE DIFFERENCE IN STANDARD DEVIATION OF PISA SCORES BY SUBJECT AND COUNTRY, 2003



Source: Analysis of OECD (2005).

FIGURE 20: SUPPLY OF AND DEMAND FOR COLLEGE-EDUCATED WORKERS IN 1970S

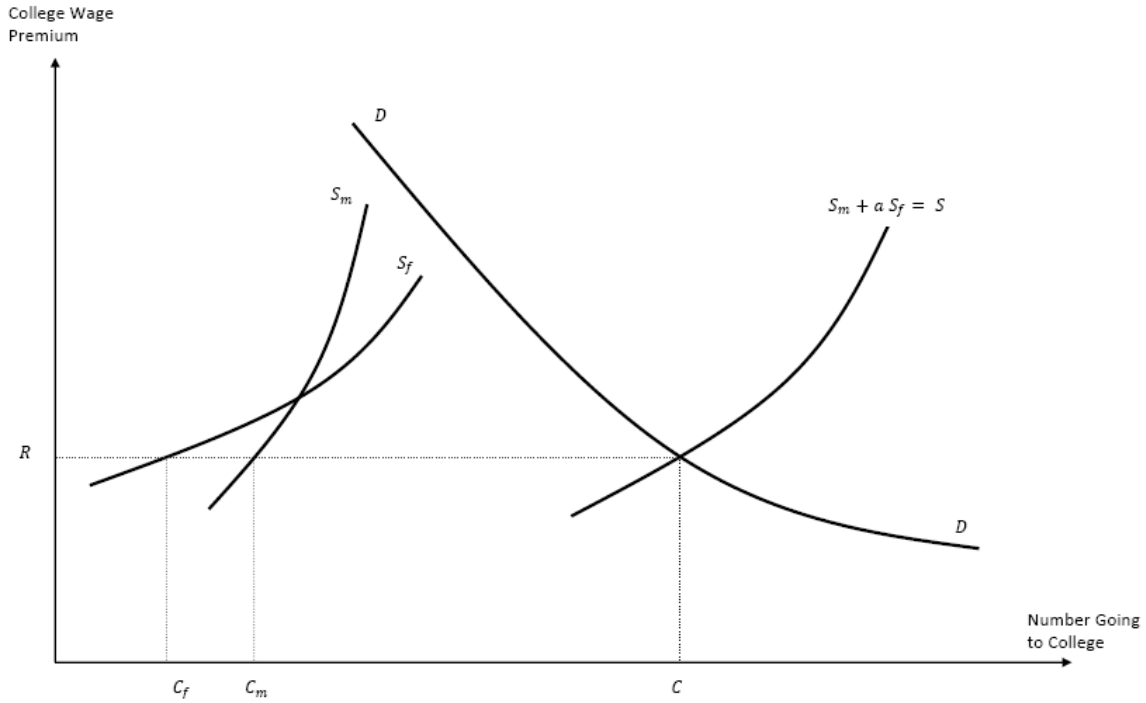


FIGURE 21: SUPPLY OF AND DEMAND FOR COLLEGE-EDUCATED WORKERS, GIVEN A SHIFT IN DEMAND ONLY

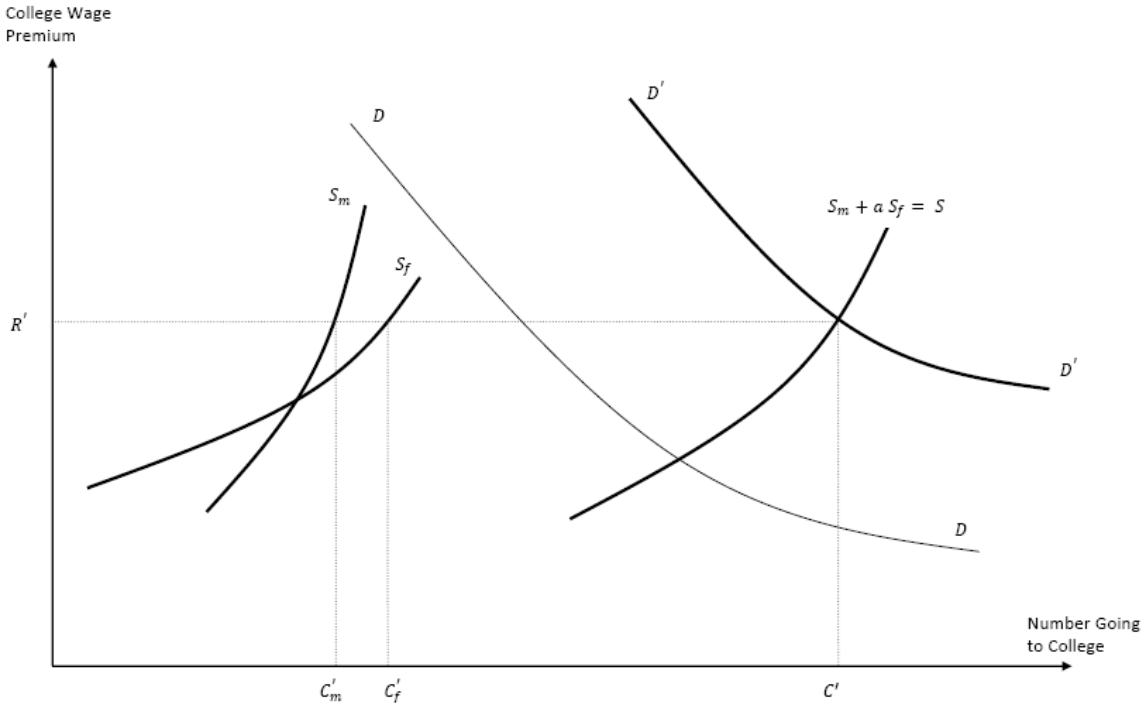


FIGURE 22: SUPPLY OF AND DEMAND FOR COLLEGE-EDUCATED WORKERS, GIVEN SHIFTS IN BOTH DEMAND AND SUPPLY