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ABSTRACT

Some economists have argued that assortative mating between men and women has increased over the last several decades, thereby contributing to increased family income inequality. Sociologists have argued that educational homogamy has increased. We clarify the relation between the two and, using both the Current Population Surveys and the decennial Censuses/ American Community Survey, show that neither is correct. The former is based on the use of inappropriate statistical techniques. Both are sensitive to how educational categories are chosen. We also find no evidence that the correlation between spouses' potential earnings has changed dramatically.

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1 Introduction

Using standard reduced form techniques, economists have argued that, over the last several decades, the United States has seen increased positive assortative mating by education (Greenwood et al., 2014). Sociologists have reached the similar but distinct conclusion that there has been an increase in educational homogamy, the tendency of men and women to find mates with the same level of education (Schwartz and Mare, 2005; Mare, 2008).[1] In contrast more structural approaches in economics such as Chiappori et al. (2015), Chade and Eeckhout (2016) and Siow (2015) have found little evidence for increased positive assortative mating although Siow does find some support for increased educational homogamy. In this paper, we reexamine changes in marital sorting and homogamy by education using standard measures and conclude that there is no compelling evidence of an increase.

Conclusions about changes in homogamy are sensitive to how educational groups are defined. In essence, if all college graduates are grouped together, homogamy increased. If we separate college graduates from those with a more advanced degree as is common in the wage structure literature (Acemoglu and Autor, 2011), then, if anything, homogamy appears to have declined.[2]

The difficulty with the assortative mating literature is, in part, due to the sensitivity of the result to the choice of categories, but it is also, to a greater degree, statistical. The ideal statistic for addressing the degree of assortative mating would be a rank-order correlation coefficient that works well when there are a large number of ties, as there are in the education distribution. Unfortunately, none exists. However, if we use either a standard Pearson correlation coefficient or standard rank-order statistics that correct for ties, we find no increase in the correlation between husband's and wife's education regardless of whether we use 5, 6 or 12 categories of education. Only if we use a rank-order correlation coefficient that does not correct for ties and five categories do we reach the conclusion that the correlation has

[1]For an interesting paper about assortative mating by degree program see Bicakova and Jurajda (2016).
[2]The finding that the choice of groupings is important is consistent with Eika et al. (2014).

increased. We also show that examining the change in the coefficient from a regression of wife's education on husband's education (or vice versa) is not informative.

Because our analysis is simple and merely statistical, we are able, in some ways, to provide a broader overview of changes in assortative mating and homogamy that complements the work of Chiappori, Salanie and Weiss and of Siow. We use both the Current Population Surveys and the decennial Censuses and American Community Surveys. We examine the evolution of educational homogamy both within and between cohorts and, depending on the question, examine changes over a period of up to fifty years.

These findings are important for two reasons. First, there is a growing concern about increasing income inequality (Esping-Andersen, 2007; Kenworthy, 2004) and its intergenerational reproduction (Chadwick and Solon, 2002). Family income disparity in the U.S. has widened sharply over the last several decades (Levy, 1998). Between 1980 and 2009, the share of aggregate income received by the lowest fifth families fell from 5.3 percent to 3.9 percent, while for the top five percent families it increased from 14.6 to 20.7 percent (U.S. Census Bureau, Historical Income Tables, table F.2). Rising rates of assortative mating are a potential explanation for some of this rise.

Second, they cast light on our theories of marriage. In Becker's (1974; 1981) theory of marriage, likes marry likes when the characteristic is complementary but not when it is substitutable. Education is likely to be complementary in consumption. But when women are not in the labor force, they are substitutes: high-skill men should marry low-skill women who then specialize in home production. Which of these two forces should dominate is unclear. But as women increasingly entered the labor force, the importance of complementarity should have increased, a point made somewhat differently by Stevenson and Wolfers (2007). Therefore, we would expect either educational homogamy or assortative mating (we discuss the distinction below) or both to increase in the light of the growth in women's labor force participation.

In addition, earnings differentials by education have increased, especially since the late

1970s (Goldin and Katz, 2000; Katz and Autor, 1999; Gottschalk, 1997; Katz and Murphy, 1992). To the extent that household income is used to purchase public goods such as quality child-care, this, too, creates pressure for positive assortative mating. Fernandez et al. (2005) establish this in an overlapping generations model and suggest a feedback mechanism between income inequality across education groups and assortative marriage in which "..[an] increase in inequality increases sorting by making skilled workers less willing to form households with unskilled workers ..." which, in turn, further increases inequality in the next generation to the extent that children inherit the educational characteristics of their parents.

2 Conceptual Background

The purpose of the section is primarily pedagogical. We believe the results in this section are known but underappreciated, at least by those who, like us, are not steeped in the theoretical literature. Therefore we have eschewed the more standard section title, "Theory." We examine the relation among homophily, which we interpret as a property of tastes or the utility function, and homogamy and assortative mating, which are the equilibrium outcomes of a process that pairs mates. We refer anyone interested in a more thorough examination of the literature to excellent reviews by Chade et al. (2016) and Browning et al. (2014).

Consider two groups of equal mass, which we will call X and Y (although the reader may wish to think of them as XX and XY). For the moment, we will assume that each individual i is endowed with a fixed amount of some characteristic, z_i. For simplicity, we will assume that the distribution of z within each group is uniformly distributed:

$$z_{ig}\tilde{}U(0, z_g^*) \tag{1}$$

with $z_y^* > z_x^*$.

Let us now consider equilibrium matching in a case of strong homophily. Individuals may match with exactly one individual from the other group, or they may choose to remain unmatched. The utility of an individual is given by

$$U_i = \begin{array}{ll} V - (z_{ix} - z_{iy})^2 & if\ matched \\ 0 & otherwise \end{array} . \tag{2}$$

Note that there is no money in the example. In technical terms, utility is strictly not transferable.[3] Each individual prefers to match with someone with the same level of z but not all will be able to do so.[4] A proportion $\left(z_y^* - z_x^*\right)/z_y^*$ of Y workers will clearly not be able to match with an X with the same characteristic because no such X exists. And the same proportion of Xs at each level of z are "surplus" matches. These surplus individuals will be sorted negatively so that within any match

$$z_{ix} + z_{iy} = z_y^* \tag{3}$$

if $V > z_y^{*2}$.[5]

It may seem surprising that an X with $z = 0$ matches with a Y with $z = z_y^*$. After all, the former strictly prefers to match with a Y with z_x^* and values doing so more than does the excess X with $z = z_x^*$ who actually makes that match. But the Y with z_x^* strictly prefers the latter match, and there is no mechanism that allows the unfortunate excess X with $z = 0$ to convince him otherwise.[6] Note that we have abstracted from the search process. To consider costly search would take us too far afield, require us to choose a search technology and be far more technical than is commensurate with our goal for this section. In general, we would expect types on the long side of their market to consider searching in proximate markets on which they are on the short side. Arcidiacono et al. (2016) provide one specification of such a model.

[3] Similar issues arise if there is some ability to transfer utility within marriage but the parties cannot make binding commitments prior to marriage (Lundberg and Pollak, 2008, see).

[4] The example thus violates the condition in Legros and Newman (2010) for positive assortative mating even under strict nontransferable utility.

[6] One can think of this in terms of the deferred acceptance algorithm which leads to a stable matching equilibrium (Roth and Sotomayor, 1990).

Our first point is a simple one: *the matching pattern depends on the matching technology as well as tastes.* Let us modify our example somewhat. Assume that each individual is endowed with some amount of money, m, measured in units of some private good and that utility is linear in the private good. Then utility is transferable[7] provided m is sufficiently large, and therefore matching will be efficient so that

$$z_{iy} = \frac{z_y^*}{z_x^*} z_{ix},$$

and there will be a set of transfers of the private good between matched individuals that will support the equilibrium.[8]

We note that while we have presented the two cases as differing with respect to the transferability of utility, they can also be interpreted as differing in the importance of homophily. As individuals put more weight on being matched with someone similar, the ability of transfers to overcome their preferences diminishes.

This leads to our second point: *without a model of the matching process, we cannot infer differences in homophily from differences in the extent of assortative matching.* For an example of a paper that uses an explicit model, see Chiappori et al. (2015).

2.1 Measuring Changes in Homogamy

Now consider the question of whether homogamy is greater with or without transferable utility in the example. Here we show our third simple point: *our conclusions about whether homogamy has increased or decreased can be very sensitive to our definition of "similar."* In the example without transferable utility a fraction z_x^*/z_y^* of matches are exact in the sense that $z_{ix} - z_{iy} = 0$. With transferable utility, the set of matches with this characteristic has measure zero. On the other hand, with transferable utility there is more homogamy in the

[7]Legros and Newman (2007) provide more general conditions which allow for nontransferable, but not strictly nontransferable, utility.

[8]That efficiency requires strictly positive assortative mating is readily verified.

sense that

$$z_{iy} - z_{ix} \leq z_y^* - z_x^*.$$

In contrast, the maximum gap without transferable utility is much larger. In practice, social scientists who have measured homogamy by education have defined homogamous marriages as those in which the educations of the partners lie in the same interval (e.g. less than high school, high school, more than high school). The argument goes through with some changes; which setting has more homogamy depends on the choice of categories.

In the empirical work below, we show that estimates of whether and how homogamy has changed are, indeed, sensitive to how we define education categories.

Finally, we note that *measured homogamy can be sensitive to shifts in the underlying distributions of the characteristics.* In either of our two cases, there is perfect homogamy if $z_x^* = z_y^*$ but homogamy is less than perfect otherwise. Thus again, we can observe a shift in homogamy with no change in the underlying utility functions or matching technology.

We will discuss below technical issues associated with measuring assortative mating in real data. However, in the examples here, it is relatively straightforward. In the case where utility is not transferable, the correlation, however measured, between z_x and z_y is imperfect while it is perfect with transferable utility. Still, it is important to recognize that, at least in the case of nontransferable or imperfectly transferable utility, the degree of assortative mating can depend on the distributions of z.

2.2 Nonmarriage

In our empirical work, we will, for the most part, ignore individuals whose marital status is other than married. Here we simply point out that changes in who marries are not at a very simple level consistent with increased homophily. When homophily is important and generates homogamy, the groups in excess supply, ys with high z and xs with low z are the least likely to get married. During our time period, women went from being a minority to being a majority of the college graduates (Goldin et al., 2006). As a consequence, we should have seen a decline in the marriage rate of college-educated women. This would be reinforced if homophily increased. In fact, the large decline in the marriage rate is at the bottom of the female skill distribution, which is more consistent with the rising value of educated women discussed in the introduction (see Figure 1).

3 Measuring Changes in Assortative Matching

Many economists are less interested in why matching might have changed than in whether it has changed since increased assortative mating would increase family income inequality. It is important to know whether increased earnings inequality has been exacerbated or mitigated by changes in marriage patterns.

In the previous section, we assumed that the underlying trait was uniformly distributed for both Xs and Ys. As a consequence, with perfect assortative matching, the correlation between the partners' educations' was also perfect. In reality, of course, there is no reason to expect the education distributions to be drawn from the same family. Moreover, education tends to be very lumpy.

Although economists tend to use correlation measures such as the Pearson correlation coefficient (r) or its square (R^2), it is more natural to use measures based on rank. Assortative matching is perfect if the individual with the highest value of z in the X group is matched with the individual with the highest z among the Ys, the second highest in each group are matched, and so on. Nothing in this description depends on being able to write z_{iy} as a linear function of z_{ix}.

It may therefore be more appropriate to use a correlation measure designed for ordered data and that does not rely on the interval properties of the data. The Spearman rank-order correlation coefficient asks precisely how closely two variables are correlated when they are rescaled by their rank. This metric is the most natural one for us to use because it corresponds strongly to the idea of correlation of ranks. Unfortunately, it does not perform particularly well in the presence of ties, of which there are many in the data.

Kendall's τ (sometimes called τ_a) asks, when comparing any two observations, whether both variables are ranked the same way. In other words, if the husband in pair x has more education than the husband in pair y, does the wife in x also have more education than the wife in y. If the answer is that she has more education, the pair is concordant. If she has less, it is discordant. τ is given by the ratio of the difference between the number of concordant and discordant pairs to the number of pairs. However, if husbands x and y (or wives x and y) have the same education, pairs can be neither concordant or discordant. Therefore, if there are many ties, it is impossible to obtain a correlation near 1 or -1. When there are ties, τ must be adjusted to take this into account. The adjusted statistic developed by Kendall is τ_b. Unfortunately even this statistic does not have good properties when there are many ties, as there are in education data. An alternative approach, Goodman and Kruskal's γ, simply drops ties and bases its estimate on those observations that can be ranked. This approach has the advantage that if two variables are, in fact, perfectly rank correlated in the absence of grouping, they will continue to be so when grouped.

To cast some light on how the presence of ties and the changing distributions of husbands' and wives' educations affect the various measures, we took the distributions of their educations at age 30 in 1960 and 2010 and assumed that they were perfectly sorted. In other words, all wives who were high school dropouts married husbands who were high school dropouts. The excess male high school dropouts married women who were high school graduates, and so on.

How did the various measures fare? Despite the ordinality of the data and the large number of ties, the standard Pearson correlation statistic does quite well, falling from .96 in 1960 to .93 in 2010 (table 1). Spearman's ρ also shows a very high correlation, which is identical to the Pearson statistic to two decimal places in both periods. In contrast, τ_a performs poorly although it shows a similar absolute decline from .71 to .68. Once we correct for ties in the form of τ_b, the estimated correlations are only slightly lower (.93 and .88) than those observed using Pearson's r and Spearman's ρ. By the design of the 'experiment,' Goodman and Kruskal's γ is 1.00 in both periods.

For completeness, we will present τ_a, but based on both their theoretical superiority and better performance in our experiment, we focus on r, ρ, τ_b and γ.

One approach that is sometimes used but should not be is to examine how regression coefficients change over time. To see this, let us return to our example with transferable utility and therefore perfect assortative mating. The regression of z_y on z_x is given by

$$z_y = 0 + \frac{z_y^*}{z_x^*} z_x.$$

In this special case, the regression coefficient depends only on the relative magnitudes of the top of the z distributions.

More generally, the Pearson correlation coefficient is

$$\rho = \frac{\sigma_{xy}}{\sigma_x \sigma_y}$$

while the regression coefficient is

$$\begin{aligned} \beta &= \frac{\sigma_{xy}}{\sigma_x^2} \\ &= \frac{\sigma_y}{\sigma_x} \rho. \end{aligned}$$

In other words, while an increase in the regression coefficient can reflect an increase in the Pearson correlation coefficient, it can also reflect an increase in the variance of women's educational attainment relative to the variance of men's education. A simple check is to estimate the reverse regression since

$$\beta^R = \frac{\sigma_x}{\sigma_y} \rho.$$

We will see that, as they must, since the Pearson correlation coefficient is roughly constant, regressing wife's education on husband's education and the reverse give opposite results.

4 Data

We rely on two data sets for our analysis. Although we show results from both of our data sources, our reconsideration of educational homogamy relies primarily on the March Current Population Surveys from 1970 through 2010 as standardized by IPUMS-CPS. The advantage of the CPS for this part of the analysis is that we can clearly attribute a break in the level of homogamy to a change in the coding of the education variable. For this part of the analysis, we limit the data to married non-interracial white and black couples in which the wife was aged 35-44 at the time of the survey. We have replicated most of our results using only white couples and get similar results (available upon request). Because imputation flags for education are available only after 1987, for consistency we keep imputed values. This gives us 324,717 couples. In addition because it is unclear what weights would be correct, we provide unweighted estimates. However, our experimentation suggests that the choice of weights has little effect on the results.

For the analysis of assortative mating, for consistency with the prior literature, we rely primarily on the 1960-2000 decennial censuses and the 2010 American Community Survey as standardized by IPUMS-USA, but replicate the results using the CPS. We keep non-interracial white and black married couples. We drop observations with any type of imputation for race, education, or wife's age (flag variables for race and education are not available for the 1960 census). Again we report unweighted results. We created the six-category measure of educational attainment using the following: fewer than 10 years of schooling; 10 to 11 years of schooling; 12 years/high school graduate; 1 to 3 years of college completed (some college, no degree or associate degree); 4 years of college/Bachelor's degree; more than 4 years of college (Master's, professional, or doctoral degree). We created the twelve-category measure of educational attainment using the following recoding: No School completed, Nursery School, Kindergarten = 0 years; 1st through 4th grade = 2.5 years; 5th through 8th grade =6.5 years; 9th grade = 9 years; 10th grade = 10 years: 11th grade = 11 years; 12th grade, high school graduate, GED or Some college, but less than 1 year= 12 years; Some college, no degree = 13 years; Associate degree or two years of college = 14 years; Three years of college = 15 years; Bachelor's degree = 16 years; Master's degree, professional or doctorate degree = 17 years.

A subset of the basic matching information using the census data is provided in table 2 which shows the percentage with different combinations of education using six categories of education among couples age 30-34. We will use these data primarily to examine assortative mating. Nevertheless, we note that we do see a very small increase in homogamy between 1960 (the 1926-30 cohort) and 1990 (the 1956-60 cohort). There is a large increase between 1990 and 2000 (the 1966-1970) cohort which is then reversed between 2000 and 2010. As noted above, we rely primarily on the CPS when we analyze homogamy. This is because coding changes across censuses are particularly problematic for the analysis of homogamy. From 1960 to 1980 educational attainment was measured using a question about years of schooling. By contrast, in the post-1980 censuses and the ACS, a person's educational attainment was coded in a very different way, using a credential-attained question. Additionally, all samples in and after 2000 contain the detailed category "Some college, but less than 1 year" which appears to have been treated as "completed high school" in other years. The change in the census question content introduces some discontinuities in the data series. Changes in sorting patterns between 1980 and 1990, as well as between 1990 and 2000 should be interpreted with some caution.

5 Results

5.1 Educational Homogamy

In this sub-section we examine the sensitivity of the pattern of homogamy to the use of different grouping criteria. There are, in our assessment, potentially twelve categories that can be determined consistently over the entire period. Moreover, there is no pair of adjacent groups in which both husband and wife fall (e.g. both husband and wife are in one of the two groups 5th or 6th grade education or 7th or 8th grade education) for which wife's education is not predictive of husband's education. For example, among wives with educational attainment of 5th through 8th grades and whose husband has a 5th through 8th grade education, wives with a 7th or 8th grade education are more likely to be married to a man with a 7th or 8th grade education than are wives with a 5th or 6th grade education. The decision to combine categories depends largely on issues of sample size and introspection about what are likely to be important social cleavages.

We note that there was a substantial change in the distribution of education over the period we study. In 1970, over half of wives age 35-44 were high school dropouts. Many of these had less than a 10th grade education. Similarly over 60 percent of their husbands had not completed high school and roughly one-quarter had less than a 10th grade education. In contrast, only 2 percent of the wives and 8 percent of the husbands had more than four years of college. From the perspective of 1970, it seems plausible that we should divide dropouts into two groups but combine all college graduates.

However, by 2010, the situation had changed substantially. Individuals with less than a 10th grade education were relatively rare, about 5 percent of both husbands and wives, and only about 3 percent of each group had a 10th or 11th grade education. In contrast, 14 percent of each group had gone beyond four years of college. From the perspective of 2010, it seems plausible that we should divide college graduates into two groups but combine all dropouts.

Following the sociological literature, we define homogamous marriages as those in which husband and wife fall into the same education category. To test the sensitivity to choice of categories of estimates of the trend in homogamy, we experiment with the four possible decisions regarding combining or separating the two dropout categories and similarly for the two college graduate categories.

Before we do so, however, it is important to point out that, regardless of our choice of categories, the scope for homogamous matches increased substantially between 1970 and 2010 because the education distributions had become much more similar. In 1970, 47.88 percent of the wives were high school graduates with no additional education compared with only 34.83 percent of the husbands. This alone reduces the potential proportion of homogamous marriages to 86.95%. Similar considerations, reduce this maximum to 84.63 percent for some choices of categories. In contrast, in 2010, there is no large discrepancy in the proportion of husbands and wives in any education category. Consequently, depending on the choice of categories, between 94.33 and 94.63 percent of marriages could be homogamous. Under these circumstances, it would not be surprising to see homogamy increasing even with no change in preferences.

Figure 2 shows the trends in homogamy for the four choices of categories. In is evident that different education group definitions suggest different conclusions about the pattern of homogamy. If we follow Schwartz and Mare and categorize educational attainment as follows (Schwartz and Mare, 2005): $\prec 10$; 10-11; 12-high school graduates; 13-15-have some college; 16+-at least college graduates (i.e. we combine the high-education groups), the trend (dashed line, triangle markers) shows a steady increase in the proportion of husbands and wives with the same education levels, from 48 to 57 percent between 1970 and 2010. However, if we separate those with a college degree from those with a more advanced degree[9] (solid line, triangle markers), the previous conclusion no longer holds: homogamy seems to have remained rather stable, a 2 percentage point increase across four decades almost all of

[9]Six distinct groups: $\prec 10$; 10-11; 12-high school graduates; 13-15-have some college; 16-college graduates; and, 16+-post-graduates.

which is attributable to a jump around 1992 and therefore possibly due to the change in the education variable in the Current Population Survey. Note that sharp jumps over a small number of years are highly implausible. We are using 35-44 and thus losing and gaining only about one-tenth of the age group each year. Barring very high rates of divorce and/or remarriage, changes in homogamy should be gradual.

Interestingly, homogamy, if anything, appears to have declined when the groups are defined as is common in the wage structure literature (Acemoglu and Autor, 2011), separating the college graduates from those having a more advanced degree, and merging the high school dropouts (solid line, x markers): $\prec$ 12-high school dropouts; 12-high school graduates; 13-15-have some college; 16-college graduates; and, 16+-post-graduates. This is considered the most appropriate grouping reflecting the educational heterogeneity and the well-chosen attainment levels with a socioeconomic significance when the fraction of college graduates holding a postgraduate degree has dramatically increased over time (Card and Lemieux, 2001), while $\prec$ 10 category is shrinking among high school dropouts. Thus, by grouping together all those with at least a college degree, studies overlook a significant source of educational diversity and overrate the increase in homogamy over time. For completeness, a series in which those that are at least college graduates are grouped together but those that are high school dropouts are disaggregated is shown. Homogamy rates rise but modestly (dashed line, x markers).

We largely confirm the visual analysis with the regression results show in table 3. In each case, we regress the homogamy measure on a time trend and a dummy variables for 1992 and later to allow for the possibility that the variable change increased measured homogamy. In column 1, we collapse the two highest education categories and find no effect of the 1992 change but an increasing trend in homogamy of about one-quarter percent per year. In contrast, when we do not combine these two categories, the coefficient falls by almost an order of magnitude. The implied increase in homogamy over the forty years is less than two percentage points. Most of the change can be attributed to a one-time modification of the

Current Population Survey.

When we combine the two groups of high school dropouts, we again find a large effect of the question change, but our conclusion about the time trend is reversed. As might be expected, combining both categories produces an intermediate result, with only a modest upward trend in homogamy.

5.2 Assortative Matching over the Life Cycle and across Cohorts

Table 4 shows the correlation between wives' and husbands' education using the measures discussed earlier (Kendall's τ_a and τ_b, Goodman and Kruskal's γ, Pearson correlation r, and, Spearman's rank correlation ρ) for five cohorts and three age groups. In the upper panel, we group education into six categories ($\prec$ 10; 10-11; 12-high school graduates; 13-15-have some college; 16-college graduates; and, 16+-post-graduates). Using all levels of education at the lowest possible level of aggregation (twelve categories - Panel (b)) gives similar patterns of correlation.

The broad picture from the table does not support the conclusion that the correlation between husbands' and wives' education has increased. The largest changes in the data are an increase of .04 for 30-34 year old women between the 1926-30 and 1966-70 cohorts using γ and a decrease of .05 for 50-54 year old women between the 1926-30 and 1956-60 cohorts using γ, τ_b, and ρ.

For 30-34 year olds, all five measures show a pattern of increasing correlation between the 1926-30 and 1946-50 cohorts followed by a decline in the correlation between the later cohort and the 1966-70 cohort. However, the changes are not large. The two rank-order correlation measures that adjust for ties suggest an increase of .02 (τ_b and γ) while the Pearson correlation shows an increase of .01 (r) over the full period, none of which is large. And since all the measures can be influenced by changes in the distribution of education, we conclude that there is little evidence of an increase in correlation over the entire period.

For women aged 40-44 years, the results are largely similar. All measures show a modest increase in the correlation between the 1926-30 and 1946-50 cohorts and, a decline between the 1946-50 and 1966-70. None of the correlation measures shows a large change over the full period. Again, the most plausible measures τ_b, γ, ρ, and, r give no evidence of a long-term trend, with one showing no trend over the period, one showing a decrease of .02 and two showing a decline of .01. Given the limitations of the measures, we again conclude that there is little evidence to support an increase in assortative mating across cohorts.

When we look at the data for 50-54 year old women, a clear pattern emerges. Although we can only follow this age group through the 1956-60 cohort, using every measure, we detect a decline in the correlation between husbands' and wives' educations. These declines are most notable using the preferred measures ($\tau_b : -.05$; $\gamma : -.05$; $\rho : -.05$; $r : -.04$).

Table 5 repeats the analysis using the data from the censuses and the 2010 ACS. We will not repeat the summary of the table. With only relatively minor differences, the two data sets reveal the same patterns.

In recent generations, women with a college degree increasingly delayed marriage to older ages, and to a greater extent, than women with either a high school degree or some college (Goldin, 2004). Delayed marriages and rising divorce rates for much of the 20th century (Stevenson and Wolfers, 2007) contribute to thicker marriage markets later in life. As such, one might suspect differences in assortative mating over the life cycle. However, the earlier cohorts also show considerable stability over the life-cycle. If anything, we see some increase in assortative matching between 1970 and 1980 for the oldest cohort in table 4. All measures increase slightly, generally by .01, but table 5, using the CPS shows slight decreases. In contrast, using the censuses, there is some slight evidence of decreasing assortative matching for the 1936-40 cohort between 1980 and 1990. All the measures of correlation fall but the changes are very small, but again this does not hold up using the CPS. For the three youngest cohorts, we see fairly consistent evidence of small declines in assortative matching as the cohort ages from its early 30s to its early 40s. However, the declines are generally modest (0.03). A similar pattern holds in the CPS.

Our results differ markedly from Greenwood et al. (2014) who find a sharp increase in τ_a using five educational categories and 25-54 year olds from 1960 to 2002. We have largely replicated their results on our cenus/ACS data. In our estimates this one measure of correlation increases markedly from .32 to .37 from 1960 to 2010. However, r drops by .01; γ drops by .08; τ_b drops by .02, and ρ increases by a mere .01.[10]

5.3 Regression and Reverse Regression

We consider the regression between a wife's educational level and her husband's, as in Greenwood et al. (2014). They regress wife's education on husband's education and find that the coefficient on husband's education has increased noticeably. We present similar results in the first (and third) column of table 6, which shows the results of estimating the following equation for married couple j, observed in year t:

$$edu^w_{jt} = c_1 + \alpha_1 edu^h_{jt} + \Sigma_{t=1970,\ldots,2010}\beta_t edu^h_{jt} + \lambda_t + \epsilon_{1jt}, \tag{4}$$

where edu^w_{jt} and edu^h_{jt} are the wife's and the husband's education,[11] respectively; husband's effect varies by year; and λ_t is a vector of year effects.

However, as discussed above, since the coefficient on spouse's education is the covariance between the education levels divided by the variance of the right-hand-side spouse's education, the regression coefficient can increase if either the covariance of education increases or the variance of the right-hand-side spouses education declines. Moreover, we have already seen that ρ, the Pearson correlation between the spouse's education levels, was roughly constant over this period. Combining the constancy of ρ with the increase in β tells us that the variance of husbands' education increased relative to the variances of wives' education.

[10]Details available upon request.

[11]We estimated the equations using both six and twelve education categories.

Therefore, if we regress wife's education on husband's education:

$$edu_{jt}^{h} = c_2 + \alpha_2 edu_{jt}^{w} + \Sigma_{t=1970,...,2010} \beta_t^R edu_{jt}^{w} + \lambda_t^R + \epsilon_{2jt}, \quad (5)$$

where the variables and parameters are defined analogously to those in (4), we expect that β^R will be decreasing over time, which is confirmed in the second (and forth) column of table 6.

Table *7* replicates these results using the CPS. The results are, if anything, stronger.

In sum, the regression results do not support the view that assortative matching has increased.

5.4 Wages or Education?

The increased wage inequality starting during the 1970s and the rapid increase in the labor force participation of married women could have increased assortative mating on wages even if there was no increase in sorting based on education. Measuring assortative mating on wages is challenging because there is still significant nonparticipation by married women.

Therefore we do not fully address this question. Instead we ask whether, given the negligible trends on sorting on education that we observe, increasing returns to education could nevertheless have increased the correlation of wages. Note that assortative mating is essentially an ordinal concept. Do the individuals with the highest values of some characteristic marry each other? Changes in the distribution of the underlying characteristics do not change sorting (except for issues related to ties). If the characteristics have no mass points and we replace the characteristic, x, by $\exp(x)$, the correlation between spouses characteristics can change even if who marries whom does not.

We undertake an exercise similar to Gonalons-Pons and Schwartz (2015) in which we assign each spouse the mean earnings of workers his/her year/race/sex/education/age cell.[12]

[12] In contrast to Gonalons-Pons and Schwartz, we do not condition on occupation which may be endogenous to the matching outcome.

We perform this calculation using both six and twelve education categories. We then calculate the Pearson correlation coefficient by age category (30-34, 40-44, 50-54) for 1960, 1970, 1980, 1990, 2000 and 2010 using the decennial Censuses and the ACS.

Consistent with declining wage inequality between 1960 and 1970, we observe either a decline in the correlation or no change whether we look within a cohort or across cohorts in the same age range (see table 8). Between 1970 and 1980 and between 1980 and 1990, the pattern is somewhat inconsistent. Between 1990 and 2000, we observe either an increase in the correlation or no change. However, none of the observed changes appears to be large. The largest absolute change in correlation we observe is using six education categories for the cohort born in 1946-50 for which the correlation increased from .494 to .556 between 1980 when they were 30-34 and 1990 when they were 40-44.

Thus we find little evidence of large changes in the correlation of spouses' potential earnings.

6 Conclusion

Our results show clearly that with appropriate statistical techniques, there is no evidence that assortative mating based on education has changed substantially over the last fifty years. Evidence for increased homogamy is very sensitive to how we define education categories. Overall, we conclude that there is little evidence to support the conclusion that such homogamy has increased. The absence of an increase in assortative mating based on educational attainment does not preclude increased assortative mating based on potential earnings, but it would be somewhat surprising to find no increase in sorting on education if there had been a dramatic increase in sorting on potential earnings. At the same time, it is also important to distinguish between sorting, which is a largely ordinal concept, and correlation which is cardinal. Changes in the distribution of wages can change the correlation between spouses' earning even in the absence of a change in sorting. We do not address this directly but do show that when we assign individuals the mean earnings of full-time/year-round workers with similar characteristics, there do not seem to be large changes in the correlation of wages.

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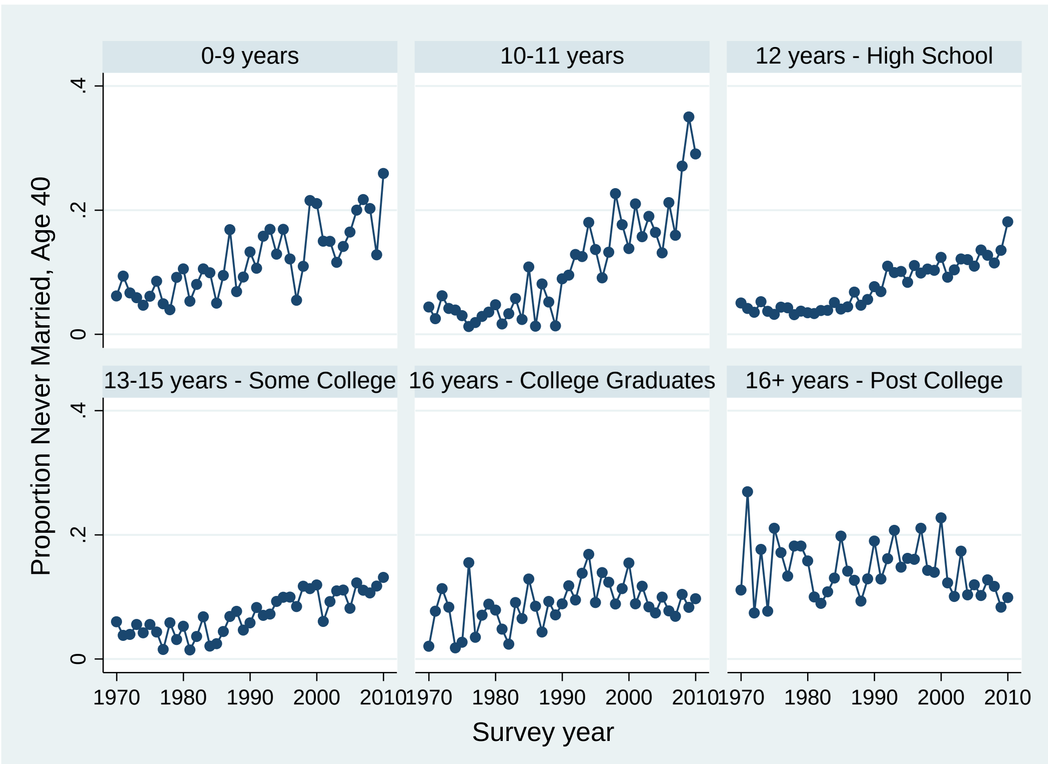
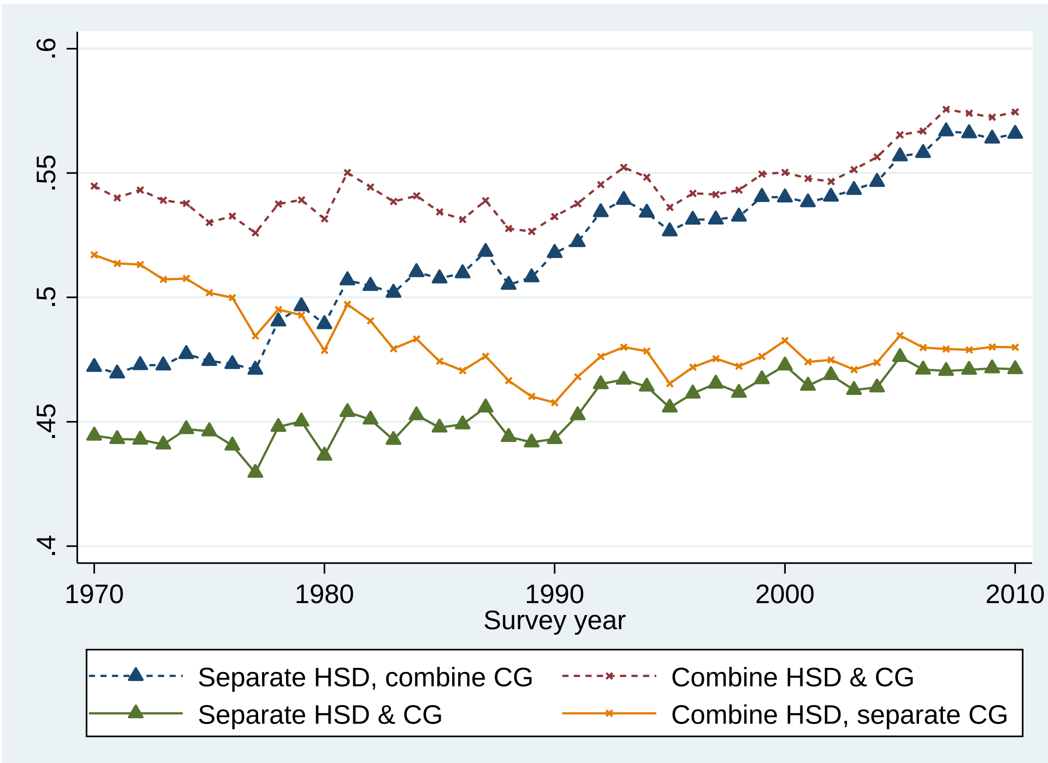
Figure 1: Never Married Trends By Education Category, Age 40



Source - March CPS 1970 - 2010.
Notes - White and black women aged 40. Six education categories: $\prec$ 10 years, 10-11 years, 12 years/High school, 13-15 years/some college, 4 years of college, 4+ years of college.

Figure 2: Homogamy Rate



Source - March CPS 1970 - 2010.
Notes - Married white and black women aged 35 - 44. Solid-triangles: $\prec$ 10 years, 10-11 years, 12 years/High school, some college, 4 year of college, 4+ years of college; Solid-X: $\prec$ 12 years, 12 years/High school, some college, 4 year of college, 4+ years of college; Dashed-triangles: $\prec$ 10 years, 12 years/High school, some college, 4+ years of college; Dashed-X: $\prec$ 12 years, 12 years/High school, some college, 4+ years of college.

Table 1: Educational Assortative Mating under Perfect Matching

Cohort	1930	1980
r	0.96	0.93
γ	1.00	1.00
τ_b	0.93	0.88
τ_a	0.71	0.68
ρ	0.96	0.93

Notes - The educational attainment distributions at age 30 by sex are derived from the 1960 American Census of Population, and 2010 American Community Survey. Sample consists of white and black individuals. Given these distributions, we start with a population of 100 individuals of each sex, and assuming perfect sorting build a hypothetical distribution of wives' and husbands' education across the two cohorts (1930 and 1980). Finally, we compute the different correlations. r - Pearson's r; γ - Goodman and Kruskal's gamma; τ_a and τ_b - Kendall's tau a and b; ρ - Spearman's rho. Six education categories: 0-9 years; 10 - 11 years; 12 years/High school degree (HS); Some college (SC); 4 year of college (CG); 4+ years of college (PC).

Table 2: Distribution of Wive's and Husband's Education across Cohorts (Wives Aged 30-34)

Husband's Educational Attainment	Wives' Educational Attainment						
Cohort 1926-1930	0 - 9	10 - 11	HS	SC	CG	PC	Total
0 - 9	15.95	6.07	8.43	0.85	0.15	0.04	31.49
10 - 11	3.56	4.12	6.53	0.74	0.17	0.03	15.16
HS	3.6	4.46	16.81	2.64	0.67	0.14	28.33
SC	0.7	1.12	5.21	2.55	0.76	0.14	10.47
CG	0.18	0.36	3.16	2.17	1.99	0.3	8.17
PC	0.1	0.19	1.62	1.85	1.84	0.79	6.38
Total	24.1	16.31	41.76	10.81	5.57	1.45	100
N of Obs	47,970						
Homogamy	42.21						
Cohort 1936-1940	0 - 9	10 - 11	HS	SC	CG	PC	Total
0 - 9	8.31	4.12	6.52	0.61	0.12	0.04	19.72
10 - 11	2.29	3.26	5.4	0.53	0.12	0.05	11.65
HS	3.1	4.87	23.6	3.2	0.86	0.25	35.88
SC	0.6	1.01	7.06	3	1.01	0.25	12.92
CG	0.16	0.22	3.43	2.63	2.58	0.48	9.5
PC	0.07	0.16	2.38	2.67	3.34	1.71	10.34
Total	14.52	13.64	48.39	12.64	8.03	2.77	100
N of Obs	41930						
Homogamy	42.46						
Cohort 1946-1950	0 - 9	10 - 11	HS	SC	CG	PC	Total
0 - 9	3.92	1.71	3.66	0.53	0.08	0.05	9.95
10 - 11	1.07	1.52	3.31	0.57	0.1	0.05	6.62
HS	1.91	2.95	23.33	4.75	1.21	0.52	34.67
SC	0.5	0.78	9.27	6.61	1.89	0.93	19.98
CG	0.07	0.13	3.63	4.17	4.07	1.51	13.58
PC	0.07	0.08	2.14	3.78	4.44	4.69	15.2
Total	7.54	7.16	45.35	20.41	11.79	7.75	100
N of Obs	272632						
Homogamy	44.14						
Cohort 1956-1960	0 - 9	10 - 11	HS	SC	CG	PC	Total
0 - 9	1.41	0.62	1.53	0.48	0.06	0.02	4.12
10 - 11	0.51	1.02	2.48	0.87	0.09	0.03	5.01
HS	0.95	2.09	19.26	8.81	1.77	0.44	33.33
SC	0.31	0.7	9.64	14.8	4.15	0.98	30.59
CG	0.04	0.08	2.48	6.14	7.37	1.73	17.82
PC	0.02	0.02	0.62	2.22	3.77	2.49	9.14
Total	3.23	4.53	36.02	33.32	17.21	5.69	100
N of Obs	304091						
Homogamy	44.94						
Cohort 1966-1970	0 - 9	10 - 11	HS	SC	CG	PC	Total
0 - 9	1.64	0.43	1.34	0.3	0.06	0.03	3.8
10 - 11	0.36	0.73	2.19	0.67	0.13	0.04	4.11
HS	0.9	1.56	22.31	9.71	3.78	0.94	39.19
SC	0.15	0.26	7.23	9.18	4.88	1.23	22.93
CG	0.03	0.05	2.61	4.53	10.3	3.07	20.59
PC	0.02	0.01	0.67	1.31	4.01	3.35	9.37
Total	3.1	3.04	36.35	25.69	23.16	8.66	100
N of Obs	230798						
Homogamy	47.51						
Cohort 1976-1980	0 - 9	10 - 11	HS	SC	CG	PC	Total
0 - 9	2.23	0.32	1.1	0.4	0.13	0.03	4.2
10 - 11	0.28	0.46	1.25	0.69	0.12	0.02	2.82
HS	0.78	0.9	13.42	9.51	4.53	1.66	30.8
SC	0.2	0.25	5.23	9.96	6.34	2.61	24.59
CG	0.04	0.04	1.88	4.35	12.09	6.03	24.43
PC	0.01	0	0.51	1.26	5.2	6.19	13.16
Total	3.55	1.97	23.39	26.15	28.4	16.55	100
N of Obs	38953						
Homogamy	44.35						

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population and the 2010 American Community Survey. Sample consists of white and black married women. Six education categories: 0-9 years; 10 - 11 years; 12 years/High school degree (HS); Some college (SC); 4 year of college (CG); 4+ years of college (PC).

Table 3: Regressions of Homogamy

VARIABLES	(1) Separate HSD Combine CG	(2) Combine HSD Combine CG	(3) Separate HSD Separate CG	(4) Combine HSD Separate CG
Year	0.0024***	0.0006*	0.0004***	-0.0015***
	(0.000)	(0.000)	(0.000)	(0.000)
Year>=1992	0.0007	0.0066	0.0129***	0.0188**
	(0.004)	(0.006)	(0.003)	(0.007)
Constant	-4.3527***	-0.5822	-0.3625	3.4080***
	(0.310)	(0.553)	(0.218)	(0.643)
Observations	41	41	41	41
R-squared	0.958	0.538	0.833	0.530

Notes - See notes for figure 1. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Educational Assortative Mating across Cohorts and over the Lifecycle

Cohort	1926-1930	1936-1940	1946-1950	1956-1960	1966-1970
Panel (a) - Six Education Categories					
Age 30 - 34					
r	0.59	0.61	0.63	0.58	0.60
γ	0.64	0.67	0.69	0.65	0.66
τ_b	0.50	0.52	0.54	0.50	0.52
τ_a	0.37	0.38	0.41	0.37	0.38
ρ	0.58	0.60	0.63	0.58	0.59
Age 40 - 44					
r	0.59	0.60	0.60	0.56	0.59
γ	0.64	0.66	0.65	0.62	0.62
τ_b	0.50	0.52	0.52	0.48	0.49
τ_a	0.38	0.38	0.39	0.35	0.37
ρ	0.58	0.60	0.60	0.55	0.57
Age 50 - 54					
r	0.59	0.58	0.58	0.55	
γ	0.65	0.63	0.64	0.60	
τ_b	0.51	0.50	0.50	0.46	
τ_a	0.38	0.37	0.37	0.34	
ρ	0.59	0.58	0.58	0.54	
Panel (b) - Twelve Education Categories					
Age 30 - 34					
r	0.60	0.60	0.63	0.58	0.61
γ	0.49	0.51	0.53	0.49	0.50
τ_b	0.60	0.63	0.65	0.60	0.63
τ_a	0.40	0.39	0.42	0.38	0.39
ρ	0.60	0.61	0.63	0.57	0.59
Age 40 - 44					
r	0.60	0.60	0.59	0.56	0.59
γ	0.49	0.51	0.50	0.47	0.48
τ_b	0.60	0.63	0.61	0.59	0.59
τ_a	0.40	0.39	0.40	0.35	0.38
ρ	0.59	0.61	0.60	0.55	0.57
Age 50 - 54					
r	0.60	0.57	0.58	0.56	
γ	0.50	0.49	0.49	0.45	
τ_b	0.61	0.60	0.61	0.57	
τ_a	0.40	0.38	0.37	0.35	
ρ	0.60	0.58	0.58	0.54	

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population and the 2010 American Community Survey. Sample consists of white and black married women. Panel (a): 0-9 years; 10 - 11 years; 12 years/High school degree; Some college; 4 year of college; 4+ years of college. Panel (b): 0-Kindergarten; Grade 1 - 4; Grade 5 - 8; Grade 9; Grade 10; Grade 11; High school (12 years); 1 year of college; 2 years of college; 3 years of college; 4 years of college; 4+ years of college.

Table 5: Educational Assortative Mating across Cohorts and over the Lifecycle – CPS Data

Cohort	1926-1930	1936-1940	1946-1950	1956-1960	1966-1970
			Six Education Categories		
			Age 30 - 34		
r		0.63	0.66	0.62	0.65
γ		0.71	0.71	0.68	0.68
τ_b		0.54	0.57	0.53	0.54
τ_a		0.40	0.43	0.40	0.41
ρ		0.62	0.65	0.61	0.62
			Age 40 - 44		
r	0.61	0.61	0.62	0.61	0.63
γ	0.67	0.67	0.67	0.65	0.66
τ_b	0.52	0.52	0.53	0.51	0.53
τ_a	0.38	0.39	0.40	0.38	0.41
ρ	0.60	0.60	0.61	0.58	0.61
			Age 50 - 54		
r	0.59	0.65	0.61	0.60	
γ	0.66	0.72	0.65	0.63	
τ_b	0.51	0.56	0.52	0.50	
τ_a	0.38	0.42	0.40	0.38	
ρ	0.59	0.65	0.60	0.58	

Notes - Data are derived from 1970; 1980; 1990; 2000 and 2010 CPS. Sample consists of white and black married women. Six education groups: 0-9 years; 10 - 11 years; 12 years/High school degree; Some college; 4 year of college; 4+ years of college.

Table 6: Regression and Reverse Regression

VARIABLES	(1) Wife's Education	(2) Husband's Education	(3) Wife's Education	(4) Husband's Education
Spouse's education	0.495***	0.719***	0.511***	0.747***
	(0.001)	(0.002)	(0.001)	(0.002)
Spouse's Educationx1970	-0.010***	0.048***	-0.024***	0.022***
	(0.002)	(0.003)	(0.002)	(0.003)
Spouse's Educationx1980	0.023***	0.036***	0.001	0.020***
	(0.002)	(0.002)	(0.002)	(0.002)
Spouse's Educationx1990	0.033***	-0.039***	0.004**	-0.048***
	(0.002)	(0.002)	(0.002)	(0.002)
Spouse's Educationx2000	0.045***	-0.094***	0.028***	-0.111***
	(0.002)	(0.002)	(0.002)	(0.002)
Spouse's Educationx2010	0.068***	-0.113***	0.051***	-0.127***
	(0.002)	(0.003)	(0.003)	(0.003)
1970 year dummy	0.140***	0.119***	0.557***	0.259***
	(0.004)	(0.005)	(0.025)	(0.033)
1980 year dummy	0.250***	0.298***	0.608***	0.668***
	(0.003)	(0.004)	(0.019)	(0.024)
1990 year dummy	0.476***	0.534***	0.974***	1.648***
	(0.003)	(0.004)	(0.020)	(0.025)
2000 year dummy	0.562***	0.660***	0.898***	2.474***
	(0.003)	(0.004)	(0.020)	(0.025)
2010 year dummy	0.667***	0.694***	0.898***	2.657***
	(0.006)	(0.006)	(0.036)	(0.040)
Constant	0.734***	0.404***	5.277***	2.370***
	(0.003)	(0.003)	(0.016)	(0.021)
Observations	5,158,320	5,158,320	5,158,320	5,158,320
R-squared	0.426	0.406	0.425	0.413

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population and the 2010 American Community Survey. Sample consists of white and black married women aged 25 - 54. In columns (1) and (2), education categories are: 0-9 years; 10 - 11 years; 12 years/High school degree; Some college; 4 year of college; 5+ years of college. In columns (3) and (4), education categories are: 0-Kindergarten; Grade 1 - 4; Grade 5 - 8; Grade 9; Grade 10; Grade 11; High school (12 years); 1 year of college; 2 years of college; 3 years of college; 4 years of college; 5+ years of college. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Regression and Reverse Regression – CPS Data

VARIABLES	(1) Wife's Education	(2) Husband's Education
Spouse's education	0.494***	0.772***
	(0.005)	(0.007)
Spouse's Educationx1970		
Spouse's Educationx1980	0.029***	-0.013
	(0.007)	(0.009)
Spouse's Educationx1990	0.060***	-0.061***
	(0.007)	(0.009)
Spouse's Educationx2000	0.093***	-0.104***
	(0.008)	(0.009)
Spouse's Educationx2010	0.114***	-0.121***
	(0.007)	(0.009)
1970 year dummy		
1980 year dummy	0.119***	0.179***
	(0.016)	(0.020)
1990 year dummy	0.209***	0.324***
	(0.018)	(0.021)
2000 year dummy	0.281***	0.433***
	(0.022)	(0.024)
2010 year dummy	0.389***	0.435***
	(0.021)	(0.022)
Constant	0.858***	0.517***
	(0.011)	(0.013)
Observations	107,911	107,911
R-squared	0.459	0.429

Notes - Data are derived from 1970, 1980, 1990, 2000 and 2010 CPS. Sample consists of white and black married women aged 25 - 54. Education categories are: 0-9 years; 10 - 11 years; 12 years/High school degree; Some college; 4 year of college; 5+ years of college. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Couples' Correlation in Mean Earnings across Cohorts and over the Lifecycle

Cohort	1926-1930	1936-1940	1946-1950	1956-1960	1966-1970
			Age 30 - 34		
Six Education Categories	0.600	0.551	0.494	0.520	0.530
Twelve Education Categories	0.585	0.546	0.508	0.496	0.517
			Age 40 - 44		
Six Education Categories	0.560	0.563	0.556	0.548	0.549
Twelve Education Categories	0.552	0.558	0.512	0.525	0.529
			Age 50 - 54		
Six Education Categories	0.553	0.549	0.558	0.531	
Twelve Education Categories	0.555	0.517	0.527	0.514	

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population and the 2010 American Community Survey. Sample consists of white and black married women. Each spouse is assigned the mean earnings of workers his/her year/race/sex/education/age cell. Pearson correlations are reported. Six education categories: 0-9 years; 10 - 11 years; 12 years/High school degree; Some college; 4 year of college; 4+ years of college. Twelve education categories: 0-Kindergarten; Grade 1 - 4; Grade 5 - 8; Grade 9; Grade 10; Grade 11; High school (12 years); 1 year of college; 2 years of college; 3 years of college; 4 years of college; 4+ years of college.