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THREE ESSAYS ON FEMALE LABOR SUPPLY AND ASSORTATIVE MATING

by

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to my parents

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ABSTRACT

This thesis focuses on female labor supply, human capital and assortative mating. The first chapter examines the link between the gap in spousal education and the labor supply behavior of married women over the life-cycle. Based on data from the 1965-2011 March Current Population Surveys and the National Longitudinal Study of Youth 1979, it documents that, all else equal, if the wife's education exceeds her husband's then she is substantially more likely to be employed than if she is less educated than her husband (up to 14.5 percentage points). A dynamic life-cycle model of endogenous marriage and labor supply decisions in a collective framework is formulated and structurally estimated. It establishes that the link between a husband's educational attainment and a wife's labor supply decision, at the time of marriage, produces dynamic effects due to human capital accumulation and implied wage growth. Returns to experience account for 57 percent of the employment gap observed between women who had married "down" and those who married "up". Counterfactuals also indicate that, alone, the changes in assortative mating

patterns across cohorts, which are implied by the changes in the marginal distributions of education, are able to explain a sizable proportion (roughly 25 percent) of the observed rise in married women's labor force participation. The second chapter analyzes the evolution of educational assortative mating along racial lines. Previous studies suggest that preferences have changed across cohorts in the US to produce an increase in assortative mating. The analysis in the second chapter challenges the metric of measurement for assortative mating and shows that educational assortative mating has been stable over time for blacks and whites despite social and economic changes that might have impacted individual's incentives to form a marriage. The third chapter proposes a novel instrument for catholic school attendance that exploits the abrupt shock to catholic schools' human capital in the aftermath of the second Vatican council. It shows that the positive correlation between Catholic schooling and student outcomes is explained by selection bias.

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List of Abbreviations

CPS	Current Population Survey
IV	Instrumental Variables
OLS	Ordinary Least Squares
U.S.	United States of America
LFP	Labor Force Participation

Chapter 1

Dynamic Effects of Educational Assortative Mating on Labor Supply

1.1 Introduction

This paper examines how the spousal education gap, i.e., the wife's relative education to that of her husband, affects her labor supply behavior over the life-cycle. A husband's income is an important determinant of his wife's labor supply; however, that factor alone is not enough to explain the difference in the employment rates of married women by spousal education gap. This paper highlights the role of labor supply and wage dynamics in explaining this fact. We argue that the matching decision in the marriage market sets in motion a process whose effects on women's labor participation decision persist over the life-cycle, due to the accumulation of human capital and the expectation of higher future wages. We use a structurally estimated model to empirically examine the joint decisions of labor market participation and marriage, and the extent to which path dependence effects could generate the observed difference in employment rates between women whose

husbands have a higher level of education than they do (who will be referred to throughout the paper as "married up") and those whose husbands have a lower level of education than they do (who will be referred to henceforth as "married down").

The past six decades have witnessed some major transformations. The employment rate of married women sharply increased, roughly doubling between 1965 and 2000. Over the same period, the gender education gap has reversed (Eckstein and Nagypal, 2004; Goldin et al., 2006). What is interesting but not unanticipated is that the reversal of the gender gap in education quickly translated into a reversal of the education gap within couples (Figure 1·1).

When examining labor supply behavior through the lens of spousal education gap, the following feature emerges: When a wife's education exceeds her husband's, she is significantly more likely to be employed relative to a wife whose education is equal to or lower than her husband's. This is illustrated in Figure 1·2. Most remarkable in the figure is that the gap in employment is constant and stable during a time of increasing female LFP. This pattern is not surprising in light of the basic Becker/Gronau model of household specialization (Becker, 1973; Gronau, 1977), where the efficient time allocation between market work and home production depends on the wage differential between the spouses. Put differently, the higher the husband's income, implied by his higher educational attainment, the lower the likelihood of the wife to be employed, *ceteris paribus*.

Using data from the 1965-2011 March Current Population Survey (CPS), we show that even controlling for husband's income, a wife whose education exceeds that of her husband is significantly more likely to be employed (up to 14.5 percentage points) compared to one who "married up". The persistent association between husband's education and wife's

labor supply indicates that it is not only the spouses' absolute incomes that play a role but also their relative earnings. One potential concern is that this finding could be driven by selection. That is, women who "marry up" tend to have unobservable characteristics that are associated with low labor force participation rates. We address this concern on multiple dimensions using data on ability, attitudes, and expectations from the National Longitudinal Study of Youth 1979. This analysis shows that it is unlikely that selection can explain the patterns of employment by spousal education gap.[1]

We hypothesize that the persistent association between wife's labor market participation and spousal education gap can be explained by path dependence and "lock-in" effects. At the time of marriage, women act on rational expectations. A low (high) expected wage differential between the spouses, which is the case when a female marries down (up), leads to a higher (lower) likelihood of employment for the wife. The interaction between husband's education/income and wife's labor force participation decision produces dynamic effects due to the process of human capital accumulation and its related wage growth. Employment in the current period increases the wife's work experience and leads to higher future expected wages, thus reducing the incentives to leave the labor market even when the initial incentive to work is no longer relevant. Understanding the dynamics in labor supply behavior and the matching decisions in the marriage market has important public policy implications. While there is an active literature assessing a wide range of tax and benefit policies that are designed to influence labor supply behavior the relationship between assortative mating and labor supply decisions has been so far under-explored.

We present a dynamic model of endogenous marriage formation (and dissolution) and

[1] See Appendix D for additional evidence and robustness checks.

labor supply, with heterogeneous (female and male) agents. In each period, an individual chooses whether to get married/divorced and whether to work. Individuals face five forms of uncertainty: employment (whether or not they receive a job offer), wages, probability of meeting a potential partner, match quality, and fertility. The probability of a job offer in the current period depends on the individual's employment status in the previous period, inducing persistence in employment status over time. In the model, returns to human capital accumulation/experience are endogenous. An individual's wage is determined by his/her observed human capital (schooling and experience), as well by ability, which is observed by the potential partner but not by the researcher.

Gains from marriage stem from the joint consumption of a public good, from match specific quality, and from children. In each period, with an exogenous probability, a single individual meets a potential partner. Once a potential partner is drawn, the potential couple then draws a match quality component of the partnership. The couple then decides whether to marry or whether to remain single and continue to search for a partner. To describe the decision problem faced by the couple we use the collective household model (Chiappori, 1988, 1992) in a dynamic framework with no commitment, as in Mazzocco et al. (2007). If the couple decides to get married, their match quality random component follows a Markov process during the course of their relationship.

We estimate the dynamic model (and a static version) by the simulated method of moments using a sample of white females who completed at least high school from the National Longitudinal Survey of Youth 1979 (NLSY79). The dynamic model provides a very good fit to the data, better than its static counterpart. In particular, the model replicates the pattern of assortative mating by educational attainment, and the wide

variation in labor supply across the different education groups observed in the data.

To assess the importance of the dynamic labor supply effects, we consider a counterfactual economy with no wage growth. The counterfactual findings support our hypothesis. Notably, if returns to experience were shut down, the gap in labor force participation between women who married "up" and women who married "down" would fall by about 50 percent.

In an alternative counterfactual exercise, we quantify the importance of changes in the marginal distribution of education across cohorts. Given the estimated benchmark model, when we replace the NLSY79 cohort's educational attainment distribution with that of a cohort twenty years older, the proportion of "married-down" women drops by 12 percentage points relative to the baseline model, while the one of "married-equal" women remains unchanged. Remarkably, these resulting endogenous changes in assortative mating patterns alone are able to explain a large proportion–25 percent–of the observed difference in married women's employment rates across these two cohorts.

The literature analyzing married women's labor supply decisions is voluminous, and we will not attempt to fully review it here (see Blundell and MaCurdy, 1999, for a comprehensive survey of the existing literature). There is also an extensive body of literature that examines female's labor force participation dynamics (see for example Eckstein and Lifshitz, 2011). Dependencies between an individual's past and current labor supply decisions are well established, and date back to Ben-Porath (1967). These can be generated by positive wage-based rewards for human capital accumulated via labor market experience (Eckstein and Wolpin, 1989; Altug and Miller, 1998; Olivetti, 2006), as well as by habit persistence (Altug and Miller, 1998). However, to the best of our knowledge this

is the first paper estimating a dynamic model that considers the different employment profiles associated with the spousal education gap. We show that there are substantial dynamic labor supply effects produced by the spousal education gap, working through the accumulation of labor market experience.

Our paper also contributes to a growing empirical literature estimating dynamic models of intra-household allocations and marital behavior using the collective framework. Estimating such models with endogenously evolving state variables is burdened by considerable computational complexity. Mazzocco et al. (2007) make an important contribution in extending the collective model with no commitment to an inter-temporal setting.[2] The authors document how labor supply evolves around periods of transitions in and out of marriage and there is no distinction of individuals by education levels. Our focus is on the life-cycle aspect of work decisions and on understanding the mechanism that leads to different outcomes. In addition, for our study, it is important to distinguish individuals by education.

The paper is organized as follows. Section 2 illustrates the main facts on the employment behavior of married white women, and the association between that behavior and the spousal education gap.[3] Section 3 develops the dynamic model. Section 4 presents the estimation methodology. Section 5 follows with estimation results. Section 6 provides counterfactual analysis. Section 7 concludes.

[2]Gemici and Laufer (2011) build on Mazzocco and explicitly model non-marital cohabitation as an intermediate stage between marriage and singlehood. They estimate a dynamic model of household formation and dissolution as well as fertility and labor supply. Jacquemet and Robin (2011) estimate a search and matching model of the marriage market and household labor supply.

[3]For comparison, some evidence is also presented for white married males. Non-white and white marriage markets function differently. While studying black married females' labor supply is very interesting, it is beyond the scope of this paper.

1.2 Stylized Facts

1.2.1 Trends in Educational Assortative Mating

From 1964 to 2011, the educational attainment of both men and women increased substantially. While in 1964 only 12% of men and 8% of women had completed college, by 2011 30% of men and 32% of women had a college degree.[4] Nevertheless, it is important to note that women's college graduation rates continued to rise steadily throughout, while male's graduation rates have started to stagnate in the early 80s and have remained constant since around 2000. Therefore, in the mid-1980s women's educational attainment began to surpass men's (Eckstein and Nagypal, 2004; Goldin et al., 2006). The reversal of the gender gap in education among men and women quickly translated into a reversal of the education gap among husbands and wives.

Throughout the section, we use CPS data.[5] Figure 1·1(a) depicts the cross sectional proportion of wives in same, higher and lower educational bracket than their husbands'. What stands out in the figure is the fact that the drop in the proportion of females marrying up (marrying a more educated male) is closely mirrored by the climb in the percentage of those marrying down (marrying a man with lower education).[6] Studies focusing on homogamy rates (wife and husband with same educational attainment) overlook a significant phenomenon that took place in the last decades. A cohort analysis, figure 1·1(b), reveals a similar trend of marrying down for women, starting from the birth cohort of 1910 and

[4] Level of schooling is an ordinal variable that takes on one of five values: 1=High school dropouts (HSD), 2=High school graduates (HSG), 3=Some college education (SC), 4=College graduates (CG) and 5=Post-college studies (PC).

[5] Full description of the data file can be found in A.2

[6] The mean absolute value of the education gap among couples[7] is also plotted in figure 1·1 (read off the y axis on the right) where we see that it persists stable from 1975 onwards.

continuing for 76 years to the cohort of 1986.[8]

Table 1.1 shows the distribution of wives by their husbands' level of education. Women tend to marry within the same or adjacent educational category rather than categories further away from their own. Therefore, the term marrying down (up) refers mostly to an education gap with the partner of one category. Panels (2) and (3), compare the distribution for pre (1940-45) and post WWII (1960-65) cohorts. Late Baby Boomers females (panel (3)) were more likely than the pre-WWII (panel (2)) female cohorts to marry down, across education categories (with the exception of HS graduate females).

1.2.2 Couples' Education Gap and Female's Employment

The employment rate of married women, age 25-55, increased from 1965 to 2011 for all education categories (Figure 1·2). The increase was pronounced for the HS graduate[9] and some college groups, and relatively small for the post-graduate group. While all married women are working more, note that females marrying down or equal have, historically and still today, higher employment rates. Table 1.2 presents wives' employment rates by wives' and husbands' education group. We observe the asymmetry between the upper right (women marrying down) and the lower left (women marrying up or equal) of the table.[10] The asymmetry is most pronounced among the college graduate and post-graduate women. The employment rate for a post-graduate female marrying a some college male is 80%, compared with 66% if she marries a post-graduate male - a 14 percentage points difference. For college graduate female, the employment rate is 24% lower if she married a post-

[8]The turning as well as the crossing points of the marrying down and marrying up lines coincide with the findings of Goldin et al. (2006) in their analysis on the reversal of the college gender gap - this is a statistical artifact.

[9]See FigureA.4

[10]The same phenomenon is not observed among husbands, see Table A.1

graduate husband comparing to a HS graduate husband. For the some college female, the employment rate is 62% if she is married to a HS graduate vs. 44% if she married to a post-graduate male - an 18% difference. From this table it is clear that the employment rate of women married down is about 20% higher when compared to the rate of women married up. The increase in the number of married down women over the last fifty years can explain a portion of (or be a result of) the increase in female employment over the same period.

Table 1.3 presents the marginal effects[11] of a logit model of wife's employment as a function of standard controls and two indicator variables, the first equals one if the wife is more educated than her husband and the second is set to equal one if the husband is more educated than the wife, leaving the homogamous couples as the reference group. Estimates reported in column (1) are signed as expected and significant: employment probability increases with education, and age. Being in a marriage where the wife is more educated is positively and significantly related to her employment, whereas the opposite is true for those marrying up compared to women in a homogamous marriage. The marginal effects (-0.05 for married up versus 0.05 for married down) differ substantially, and their confidence intervals do not overlap. Rosenzweig and Wolpin (1980) argued that the fertility decision is endogenous, so we excluded the presence of children as a control in the first estimation. These controls were added in column (2) to examine the extent of their effect on our main variable of interest. The estimates on married up and married down are almost identical to those in column (1). The presence of children in general, and young children in particular

[11]The marginal effects are obtained by calculating the average of the marginal effects for each individual in the sample. In assessing the individual marginal effects for dummy variables, we compute the difference in the probability when the variable equals, alternatively, one and zero.

is associated with a decline in the likelihood of being employed.

The most straightforward explanation for this phenomenon is the correlation between education and income. This draws from the literature on the allocation of time between market and non-market work within the family (Becker, 1973, 1974a, 1993; Gronau, 1977). The division of labor between spouses is based on their relative productivities in paid and unpaid work, with productivity being effectively measured by the wages they could obtain in the market. Higher educated husbands have higher market earnings and therefore their wives will spend less time in paid work and more on home production. Table 1.4 re-establishes the asymmetry phenomenon even for women married to husbands with annual earnings at the top 10%, as well as for those with husbands' annual earnings at the median (results hold for the other deciles - see Table A.2 in the Appendix). The husband's "income" effect appears unlikely to account for the wide variation in employment rates.[12] So in Table 1.3, column (3), we include a set of dummy variables for husband's annual income decile.The marginal effects fall to 3.6 percentage points for married down, and 2.9 percentage points for married up but remain statistically significant. Put differently, the wife being the more educated spouse vs. less educated than her husband is associated with a remarkable increase of 12 percent in her likelihood of being employed with respect to the mean of the dependent variable.

Alternatively, since the data is cross sectional, one can argue that husband's current income is likely to suffer from transitory measurement error or life cycle bias. Mincer (1962) in his classic paper postulated differential labor supply responses to permanent and

[12]It is not an unexpected result since recent papers have shown that women's labor supply became less responsive to their husbands' wages over the sample period (Blau and Kahn, 2007).

transitory income.[13] We re-estimated the model, adding the husband's education[14] as a long run determinant of the level of permanent income as it is less likely to suffer from bias than current income while being highly correlated with current income. From Table 1.3, column (4) it appears that, holding everything else equal, husband's education/potential income plays a role and is significantly associated with the likelihood of being employed. Though the effects are not monotonic, we should note that the probability of the wife being employed decreases when the husband is a college graduate or post graduate, compared to a husband holding a some college degree. Moreover, the married up and married down effects are similar to those displayed in column (3) and remain highly significant (4.2 percentage points for married up and 2.5 percentage points for married down). In column (5) we include both, husband's current income decile and education category. Here the current income is likely to pick up the effect of income shocks. The marginal effects for marrying up and down are again very similar, though slightly smaller (3.8 versus 4.2 percentage points for married up and 2.2 versus 2.5 percentage points for married down).

In column (6), we add MSA specific intercept terms (MSA fixed effects) to capture unobserved heterogeneity that remains constant over time. Results are practically identical and indicate that these differences are not driven by systematic MSA specific factors.[15] The size of the marginal effects in our preferred specification (column (6)) imply that being the more educated spouse (vs. being the less educated spouse) is associated with an increase of 12 percent in the wife's likelihood of being employed with respect to the

[13] Mincer (1962) in his classic paper noted that a transitory reduction in income due to the husband's brief spell of unemployment has a stronger effect on his wife's labor supply than a permanent one.

[14] Four education group dummies, HS dropout is the omitted category

[15] Results are similar when married Black females are included.

mean of the dependent variable.[16] The estimates are robust to a variety of specifications that address alternative explanations, as shown in Appendix D.1 and D.2.

Table 1.2 hinted that the effect could be stronger for the higher education groups. We run the logit model on female employment separately for each female education group (Table 1.5). Indeed, the effects are by far largest for college graduate, and post-graduate females compared to females holding some college degree, and trivial for HS graduates. For college graduate females the marginal effects of married down and married up are of 8.5 and 6.3 percentage points, respectively.

1.3 Model

Overall, the findings presented thus far confirm the explanatory power of the Becker/Gronau time allocation model to a fair extent. However, the persistence of the results associated with wife's relative education point to a more complex structure. Particularly, there are dynamic aspects to the Becker/Gronau predictions that arise out of inter-temporal dependence of actions and these are likely to be missed by the static approach. The primary incentive to work or not to work early in the marriage could also be producing considerable long term labor supply effects. The findings cannot be explained by selection in marriage or by differential in marital stability, as shown in Appendix D. Interestingly, while a positive selection on ability into "marrying down" within each education group would explain the higher employment rates of married down women, we find that the opposite is true.

The evidence, then, seems to strongly suggest that lock-in effects are at work (induced

[16] The wife's hours worked per week equation was estimated using a traditional selectivity bias correction analysis (Heckman, 1979). Marrying down (marrying up) is not associated with a significant effect on hours worked per week. The relative education position of the female within the couple seems to have an effect on the likelihood to be employed (extensive margin) but not on the intensity of work (intensive margin).

by human capital accumulation/experience), resulting in a persistent employment status. Intuitively speaking, consider a woman that married down. Consistently with standard economic models, a wife's labor supply early in marriage is a response to the husband's expected permanent income. In this respect, conditional on the husband's permanent potential income, the higher the wife's expected earnings the more likely she is to engage in paid work. The decision to work allows the accumulation of human capital. Higher work experience translates to higher wages with time through returns to experience. This increases the opportunity cost for leaving the labor market, producing a positive lock-in effect. Therefore, the propensity to leave the labor market is low. The opposite story unfolds for a woman marrying up, who, expecting a wealthier husband, interrupts her labor market participation.

To address the above issues the following are required. First, a model of marriage is needed. In addition, the framework must include labor supply decisions. This motivates the following model that builds on the approach in Mazzocco et al. (2007). In the model, in each period, agents make decisions regarding marital status, marriage or divorce, and employment. Individuals start off with a schooling level, S, and an ability endowment, φ_1 (a random draw from a normal). Fertility follows an exogenous process. Therefore, from the age at which formal education is completed, at each period, a single individual maximizes the present value of her/his utility over a finite horizon by choosing the following: (1) whether or not to work ($d \in \{0, 1\}$). Each agent is endowed with one unit of time allocated to work d, and leisure $l = 1 - d$; (2) marital status ($m \in \{0, 1\}$) − whether to marry (if she/he meets a potential partner) or continue search. When married, the individuals choose whether to stay married or separate. We assume no search for a partner

while married.

1.3.1 Preferences

Individual j ($j = H$ - Husband, W - Wife) from household i has a period utility that depends on his/her private leisure, l, public good consumption, x, total number of children, N, and match quality (if married), Q. The utility function of an individual is given by,

$$U_{itj} = \frac{\left(\frac{x_{it}}{1+\xi}\right)^{\chi}}{\chi} + \alpha_{1j} l_{itj} + \alpha_{2j} N_{it} + m_{it} Q_{it} + \alpha_{3j} m_{it} N_{it} \tag{1.1}$$

where χ governs the intertemporal elasticity of substitution, and $\xi(m_{it}; N_{it})$[17] is the consumption deflator depending on the marital status and the total number of kids. Utility from children may differ if married ($m = 1$).

1.3.2 Home Production Technology

There is a public good, x_{it}, that is produced using the domestic labor supplies of the partners as inputs. The intra-household production technology is a function of the partners' number of housework hours and the amount of goods purchased in the market for the production of the public good. At period t, the public good is produced according to the following technology:

$$x_{it} = \left(\left(1 + \sum \gamma_{1k} N_{it}^{k}\right)\left(\delta_j l_{itj} + \delta_{-j} l_{it-j} m_{it}\right)^{\varsigma} + \left(1 + \sum \gamma_{2k} N_{it}^{k}\right)\left(w_{itj} + w_{it-j} m_{it}\right)^{\varsigma}\right)^{1/\varsigma} \tag{1.2}$$

[17] $\xi(m_{it}; N_{it}) = 0.7 * m_{it} + 0.4 * N_{it}$ where 0.7 weight is given for an adult, and 0.4 to a child (OECD scale).

where $(w_{itj} + w_{it-j}m_{it})$ is the amount of market purchased goods, given by the individual's wage, and his spouse's wage if married.[18] $(\delta_j l_{itj} + \delta_{-j} l_{it-j} m_{it})$ are the effective housework hours, defined as a function of the individual leisure (and his partner leisure if married). The productivity of labor (l_{itj}) in the home production, δ_j, is gender-specific. γ_{1k} and γ_{2k} govern the extent to which the number of children in each age group shifts the productivity of housework hours and of market goods, respectively. The home production function is of constant elasticity of substitution type and the parameter ς determines the elasticity of substitution between the housework time inputs and market good inputs in the production technology. This specification allows for concavity and some complementarity between the two inputs depending on the value of ς.

1.3.3 Fertility and Children

The number of children of age group k[19] evolves according to:

$$N_{it}^k = N_{it-1}^k + n_{it}^k - o_{it}^k \tag{1.3}$$

where $n_{it}^k = 1$ if a child enters age group k at time t and zero otherwise; $o_{it}^k = 1$ if a child exits age group k at time t and zero otherwise. The probability of having another child is a function of the female's employment state in the previous period (d_{it-1W}), her marital status (m_{it}), her age and age squared interacted non-linearly with her education[20] $(S_{iW}AGE_{itW}, S_{iW}AGE_{itW}^2)$, husband's education[21] $(S_{iH}$, if married), and the total current number of children (N_{it}). The probability of having an additional child is given by

[18] We abstract from borrowing and savings decisions, so that in each period the labor income is used to purchase goods, which acts as an input into the home production technology (Eckstein and Lifshitz, 2011; Gemici and Laufer, 2011)

[19] Children are aged 0-5, or 6-18.

[20] $S_{iW} \in \{HSG, SC, CG, PC\}$

[21] $S_{iH} \in \{HS, HSG, SC, CG, PC\}$

(as in Van der Klaauw (1996)):

$$\begin{aligned} Pr(N_t = N_{t-1} + 1) \quad &= \quad \Phi(\lambda_1 d_{it-1W} + \lambda_2 m_{it} + \sum_S \lambda_3^S S_{iW} AGE_{itW} \\ &\quad + \sum_S \lambda_4^S S_{iW} AGE_{itW}^2 + \lambda_5 S_{iH} + \lambda_6 N_{it}) \end{aligned} \tag{1.4}$$

where Φ is the standard normal distribution function.

1.3.4 Labor Market

We adopt the Mincerian/Ben-Porath wage function for each individual j = H, W where experience is endogenously determined, such that:

$$ln\, w_{itj} = \varphi_{i1j} + \varphi_{2j} K_{it-1j} + \varphi_{3j} K_{it-1j}^2 + \sum_S \varphi_{4j}^S S_{ij} + \epsilon_{itj} \tag{1.5}$$

where K_{it-1j} is actual work experience accumulated by the individual. From the time at which formal education is completed, work experience evolves according to $K_{itj} = K_{it-1j} + d_{itj}$. S_{ij} denotes the predetermined individual's level of schooling. ϵ_{itj} is a gender specific zero-mean, finite-variance and serially independent error, which is uncorrelated with K and S, $\epsilon_j \sim N(0, \sigma_{\epsilon_j}^2)$. The constant term, φ_{i1j}, denotes permanent individual ability endowment (similarly to fixed effect) that is known to the individual and to his potential partner.[22]

We introduce frictions to the model. In each period t the individual receives at most one job offer. The offer arrival rates follow a logistic distribution and depend on the labor market state variables (previous period employment status, d_{it-1j}, schooling ,S_{ij}, as well

[22] Ability is assumed to be a random draw from a normal ($\varphi_{1j} \sim N(0, \sigma_{\varphi_{1j}}^2)$).

as, accumulated work experience, K_{it-1j}):

$$Prob_{itj}^{job\ offer} = \frac{exp\left(\rho_{1j} d_{it-1j} + \sum_S \rho_{2j}^S S_{ij} + \rho_{3j} K_{it-1j}\right)}{1 + exp\left(\rho_{1j} d_{it-1j} + \sum_S \rho_{2j}^S S_{ij} + \rho_{3j} K_{it-1j}\right)} \tag{1.6}$$

We implicitly assume that in each period the individual may lose his job with a probability that is negatively correlated with his accumulated experience and education. In the empirical estimation, since men's employment rate is essentially close to 100 percent, we assume that men always work, i.e., $Prob_{itH}^{job\ offer} = 1$.

1.3.5 Marriage Market and Match Quality

Every period, with probability p, a single individual meets a potential partner characterized by a level of schooling, ability, and experience. Once a potential partner is drawn, the potential couple then draws a match quality of the partnership, Q. In particular, Q consists of an education level specific measure of 'compatibility', θ^S, and of a bliss shock, Q^b,

$$Q = 1\{homogamous\}\theta^S + Q^b \tag{1.7}$$

where θ^S[23], is enjoyed by the couple when both are holding the same educational attainment; and Q^b will be normally distributed so that $Q^b \sim N(0, \sigma_Q^2)$. The couple then decides whether to marry or whether to remain single and continue search. The problem that the couple faces when they are making this decision is detailed in the household's problem section. If they decide to get married, their match quality random component follows a Markov process during the course of their relationship, so that in each period they draw a new bliss component conditional on this component's value in the previous

[23] $S \in \{HSG, SC, CG, PC\}$

period. As in Brown and Flinn (2006), as well as Gemici and Laufer (2011), we have a finite number of bliss values $Q^b \in \{Q_1^b, ..., Q_M^b\}$.[24] The probability of Q_q^b increasing to Q_{q+1}^b in the next period is given by P_Q^+ if $q <$ M. The probability of Q_q^b decreasing to Q_{q-1}^b in the following period is given by P_Q^- if $q > 1$.

The timing of events within a period is illustrated in timeline shown in Figure 1·3.

1.3.6 Household's Problem

This is a finite horizon problem. Agents stop making choices in period T[25] and each period face five forms of uncertainty: job offer arrival rates, wages, probability for a potential partner and its characteristics if single, match quality, and fertility. At the beginning of each period t, once uncertainty is realized, we assume that the marital status and the labor decisions are endogenously and simultaneously made. An agent makes choices given a vector of underlying state variables Ω_{it}. The vector contains twelve state variables: couple's schooling, age[26], accumulated experience, ability, previous work status, the number and age of the children, match quality, and the wife's Pareto weight (discussed later),

$$\Omega_{it} = \left[S_H,\, S_W,\, AGE_{itW},\, K_{iHt},\, K_{iWt},\, \varphi_{1iH},\, \varphi_{1iW},\, d_{it-1W}, N_{it},\, AGE_{it}^N,\, Q_{it},\, \mu_{tW}\right]$$

Single Household

We now characterize the value of being single at time t. We solve the model backwards starting with the decision problem in period T and Ω_{iT}. The value of being single for

[24] A discrete approximation of the continuous distribution is performed and the values are governed by the zero mean and σ_Q^2. We use a grid of five, equally-spaced, support points. See Brown and Flinn (2006) for further details.

[25] In the empirical estimation, the terminal period is set to $T = 45$ since the evidence in the data shows that marriage, employment, and fertility profiles remain stable after 45 years of age.

[26] Since we assume that men always work, husband's age and experience are perfectly correlated. In the empirical estimation we will therefore consider only his experience in the state vector.

individual j in household i, can be determined by the solution of the following problem:

$$V_{iT}^{0j}\left(\Omega_{iT}\right)=\max_{d_{iTj}}\ U_{iTj}\left(x_{iT},\, l_{iTj},\, N_{iT}^{k}\right)+\beta V_{iT+1}^{j}\left(\Omega_{iT+1}|\Omega_{iT}\right) \tag{1.8}$$

s.t.

$$x_{iT}=\left(\left(1+\sum\gamma_{1k}N_{iT}^{k}\right)\left(\delta_{j}l_{iTj}\right)^{\varsigma}+\left(1+\sum\gamma_{2k}N_{iT}^{k}\right)\left(w_{iTj}\right)^{\varsigma}\right)^{1/\varsigma}$$

$$l_{iTj}+d_{iTj}=1,\quad j=W,\, H$$

where β is the discount factor and a linear approximation is used to estimate the terminal value function at the terminal period, V_{iT+1}^{j}.[27]

Taking the solution for period T, in recursive form, the single individual's problem in any period t can be written as:

$$V_{it}^{0j}\left(\Omega_{it}\right)=\max_{d_{itj}}\ U_{itj}\left(x_{it},\, l_{itj},\, N_{it}^{k}\right)+\beta\mathbb{E}\left[V_{it+1}^{j}\left(\Omega_{it+1}|\Omega_{it}\right)\right] \tag{1.9}$$

s.t.

$$x_{it}=\left(\left(1+\sum\gamma_{1k}N_{it}^{k}\right)\left(\delta_{j}l_{itj}\right)^{\varsigma}+\left(1+\sum\gamma_{2k}N_{it}^{k}\right)\left(w_{itj}\right)^{\varsigma}\right)^{1/\varsigma}$$

$$l_{itj}+d_{itj}=1,\quad j=W,\, H$$

where $\mathbb{E}$ the expectations operator and V_{it+1}^{j} is the value function of agent j in period $t+1$.

[27] Terminal value function for a single individual is

$$V_{iT+1}^{j}\left(\Omega_{iT+1}\right)=\tau_{1j}S_{ij}+\tau_{2j}K_{iT+1j}+\tau_{3j}d_{iTW}+\tau_{4j}N_{iT+1},\quad j=W,\, H$$

Married Couple

The couple maximizes the weighted sum of spouses' utilities in marriage. The couple does not have access to commitment technology, therefore the problem can be characterized using a Pareto problem with participation constraints and in each period the problem is

$$\begin{aligned}\max_{\{d_{itW},\, d_{itH},\, m_{it}\}} \quad & \mu_{tW}\left\{U_{itW}\left(x_{it},\, l_{itW},\, N_{it}^{k},\, Q_{it}\right)+\beta\mathbb{E}\left[V_{it+1}^{W}\left(\Omega_{it+1}|\Omega_{it}\right)\right]\right\} \\ & +\left(1-\mu_{tW}\right)\left\{U_{itH}\left(x_{it},\, l_{itH},\, N_{it}^{k},\, Q_{it}\right)+\beta\mathbb{E}\left[V_{it+1}^{H}\left(\Omega_{it+1}|\Omega_{it}\right)\right]\right\} \qquad (1.10)\end{aligned}$$

s.t.

$$\begin{aligned}x_{it} &= \left(\left(1+\sum\gamma_{1k}N_{it}^{k}\right)\left(\delta_{W}l_{itW}+\delta_{H}l_{itH}\right)^{\varsigma}+\left(1+\sum\gamma_{2k}N_{it}^{k}\right)\left(w_{itW}+w_{itH}\right)^{\varsigma}\right)^{1/\varsigma} \\ U_{itW}\left(x_{it},\, l_{itW},\, N_{it}^{k},\, Q_{it}\right)+\beta\mathbb{E}\left[V_{it+1}^{W}\left(\Omega_{it+1}|\Omega_{it}\right)\right] &\geq V_{it}^{0W}(\Omega_{it}) \\ U_{itH}\left(x_{it},\, l_{itH},\, N_{it}^{k},\, Q_{it}\right)+\beta\mathbb{E}\left[V_{it+1}^{H}\left(\Omega_{it+1}|\Omega_{it}\right)\right] &\geq V_{it}^{0H}(\Omega_{it}) \\ l_{itj}+d_{itj} &= 1, \quad j=W,\, H\end{aligned}$$

where $V_{it}^{1j}(\Omega_{it}) \equiv U_{itj}\left(x_{it},\, l_{itj},\, N_{it}^{k},\, Q_{it}\right)+\beta\mathbb{E}\left[V_{it+1}^{j}\left(\Omega_{it+1}|\Omega_{it}\right)\right]$ is the value of being married for agent j that comes from the solution of the couple's problem in (9). Marriage is consensual. Therefore, each partner's value from marriage should be at least as high as the value of being single, $V_{it}^{0j}(\Omega_{it})$. Note that when $\beta=0$, individuals are not forward-looking and the model simplifies to a static structural model - no explicit reference to the future consequences of current decisions.

The household problem does not have a closed form solution and is again solved numerically using backward induction. To compute agent j's value from being married we solve the couple's problem in two steps. First, the time allocation problem is solved, ignoring the participation constraints and using the Pareto weight from the previous period, μ_{it}. When a couple first meets, the initial Pareto weight is determined by a Nash bargaining

problem that assigns both partners equal bargaining weight. Hence, in the terminal period T the planner solves the following problem:

$$\begin{aligned}\max_{\{d_{iTW},\, d_{iTH},\, m_{iT}\}} \quad & \mu_{TW}\left(U_{iTW}\left(x_{iT},\, l_{iTW},\, N_{iT}^{k},\, Q_{iT}\right)+\beta V_{iT+1}^{W}\left(\Omega_{iT+1}|\Omega_{iT}\right)\right) \\ & +\left(1-\mu_{TW}\right)\left(U_{iTH}\left(x_{iT},\, l_{iTH},\, N_{iT}^{k},\, Q_{iT}\right)+\beta V_{iT+1}^{H}\left(\Omega_{iT+1}|\Omega_{iT}\right)\right) \qquad (11)\end{aligned}$$

s.t.

$$x_{iT}=\left(\left(1+\sum\gamma_{1k}N_{iT}^{k}\right)\left(\delta_{W}l_{iTW}+\delta_{H}l_{iTH}\right)^{\varsigma}+\left(1+\sum\gamma_{2k}N_{iT}^{k}\right)\left(w_{iTW}+w_{iTH}\right)^{\varsigma}\right)^{1/\varsigma}$$

$$l_{iTj}+d_{iTj}=1, \quad j=W,\, H$$

where again a linear approximation is used to estimate the terminal value function at the terminal period, V_{iT+1}^{j}.[28] Given the current μ_{iT}, from the solution of the above problem the value of a married agent j, V_{iT}^{1j}, can be computed.

In the following step, we check whether the individual participation constraints are satisfied for the optimal time allocation. Three events can occur: *(1)* The participation constraints are satisfied for both partners, in which case they remain married or decide to marry if they just met and individual j's value is V_{iT}^{1j}. *(2)* The participation constraints are binding or violated for both partners and it is optimal to divorce[29] or not marry if they just met. Partner j's value is then V_{iT}^{0j}. *(3)* The participation constraint is violated for j but satisfied for $-j$, i.e., the former is better off single and the latter married. In this

[28] Terminal value function for a married individual is

$$\begin{aligned}V_{iT+1}^{j}\left(\Omega_{iT+1}\right) \quad = \quad & \tau_{1j}S_{ij}+\tau_{2j}K_{iT+1j}+\tau_{3j}d_{iTW}+\tau_{4j}N_{iT+1}+\tau_{5j}S_{i\text{-}j} \\ & +\tau_{6j}K_{iT+1\text{-}j}+\tau_{7j}m_{iT+1}+\tau_{8j}m_{iT+1}N_{iT+1}+\tau_{9j}m_{iT+1}Q_{iT}, \quad j=W,\, H\end{aligned}$$

[29] In the event of divorce women retain custody of their children and the husband does not pay any child support.

case, the couple will renegotiate and the weight[30] on the utility of the partner preferring to remain single, μ_j, is increased to the point where he is indifferent between being single or married. At this new Pareto weight, if participation constraints are satisfied for both they remain married (or marry). Individual j's value is the new V_{iT}^{1j}. Otherwise, the couple separates and the value for agent j is V_{iT}^{0j}.

Once the continuation values have been defined, to determine agent j's value from being married in an arbitrary period t we solve the couple's problem by solving the problem recursively using the same two step procedure described above.

1.4 Estimation

The model is estimated using the Simulated Method of Moments (SMM) . The objective of the method is to find the parameter vector $\hat{\vartheta}$ that minimizes the quadratic distance between a set of empirical (Ψ_D) and simulated moments ($\Psi(\hat{\vartheta})$). Formally the SMM estimator $\hat{\vartheta}$ solves:

$$\hat{\vartheta} = \arg\min_{\vartheta} \left[\Psi_D - \Psi(\hat{\vartheta})\right]' W \left[\Psi_D - \Psi(\hat{\vartheta})\right]$$

where ϑ is the vector of parameters of our interest; W is the weighting matrix and the weight assigned to each element of the vector $[\Psi_D - \Psi(\hat{\vartheta})]$ is the inverse estimated standard deviation of the particular data moment. Under the assumptions that the variables are stationary and ergotic, $\hat{\vartheta}$ is consistent (Pakes and Pollard, 1989).

The following lists the set of empirical moments (Ψ_D) that we aim to match : average employment rate for women by age, education, relationship status, number of kids, and spouse's relative education (down, equal, up); employment transition rates by age,

[30] For the Pareto weights, μ, we use an equally-spaced grid of 11 points.

relationship status, and number of kids; wages by gender, education, experience, spouse's relative education; wage variances by gender; average probability of giving birth by age, and education; average number of children at the age of 40 by education; percentage of married females by age, and education; transition rates between marital states by age, and education.

The parameters to estimate (ϑ) are: the seven parameters in the utility function (χ, α_{1j}, α_{2j}, α_{3j}); the twelve parameters that determine the probability of having a child (λ_1, ..., λ_6); nine parameters of the marriage marriage market and match quality (p, θ^S, μ_Q, σ_Q^2, P_Q^+, P_Q^-); the seven parameters of the household production function (γ_{1k}, γ_{2k}, δ_{-j}, δ_j, ς); the fifteen parameters that determine the wage process for females and males (φ_{2j}, φ_{3j}, φ_{4j}^S, $\sigma_{\epsilon_j}^2$); the thirteen parameters of the probability to receive a job offer for women and men (ρ_{1j}, ρ_{2j}, ρ_{3j}^S); the parameters in the terminal utility function (τ_{1j}, ..., τ_{9j}). The discount factor β is set to 0.97.

Given the individual's education, a potential partner is drawn from a conditional distribution according to the actual distribution for the NLSY79 cohort (born 1960-65). In particular, we use CPS data to generate the actual distribution of spouses' level of education and potential experience.[31] Each individual can only draw a potential spouse with an educational level no more than two level below, no more than two levels above, or at the same level of educational attainment. This restriction is not essential but is based on the consideration of geographic proximity, and that individuals search/meet potential spouses in similar circles.

The model is estimated using the 1979-2008 waves of the NLSY79. In solving the

[31] We define years of potential experience as the difference between age and years of schooling.

dynamic programming problem, we focus on women with at least a high school degree. The details of data construction are described in A.3. Most women had completed schooling by the time of marriage: among all women in our sample 92% reported "Not Enrolled" at the time of marriage and only 4% returned to school (relatively late in the marriage). Therefore, to simplify matters the initial sample is made of representative single agents reflecting the distribution of education levels observed in the data.[32] We solve the model for each agent in each period. To allow agents to follow a rich set of paths, we simulate 1000 agents for each level of schooling from the year schooling was completed until 45 years of age and produce the targeted moments.

1.5 Estimation Results

1.5.1 Parameter Estimates

Parameter estimates and their standard errors are reported in A.3. A subset of the parameters are fundamental to understanding differences in employment profiles between the different marriage categories.

Identification of the parameters determining productivity, and preferences for working and children, rely on the set of moments describing labor supply by family status and labor market transitions, by education level. Our estimated value for ς is 0.78, a reasonable degree of substitution between market goods and housework inputs. Woman's preference for working depend on her family status. It is accounted for by the shifters to the marginal housework productivity. Mothers find it more costly to take up work, particularly if children are young ($\gamma_{1,0-5} > \gamma_{1,6-18} > 0$). Young and older children have similar a similar

[32] High school graduate start at the age of 18, some college at 22, college graduate at 23, and post college at 25.

effect on marginal market goods productivity, $\gamma_{2,0-5}$ and $\gamma_{2,6-18}$ are similar in magnitude.

The wage-related parameters are identified from the wage profiles for the women in the sample and husband's earnings. We only observe wages for those who work, but the solution to the optimization problem provides the sample selection rules. The coefficients show familiar features. As compared to lower levels, a university education carries a substantial wage premium. An extra year of experience translates to a reasonable about 5 and 6 percent increase in wages[33], for females and males, respectively. Men exhibit higher returns to education and work experience.

Female's job arrival rate is identified from data moments on transitions into and out of employment, again, by education level. As we would expect, the arrival rate increases with education and is higher when on the job. The estimate on work experience in the job arrival rate function is negative but small. This is because the dynamics of work experience, underlying the dynamics of job arrival rate is loosely identified from the profile of employment with age.

The transition probabilities that define the dynamics of the match quality Q are important in the model. These, as well as the other match quality parameters, are identified from the profile of marriage rate with age and also the empirical transition matrix between marital statuses, by education level. The probability of a positive and negative match quality shock are estimated to be 22 and 24 percent, respectively. Preference parameters for assortative mating, θ^S, confirm that compatibility is valued, and more so among the more educated.

[33]Olivetti (2006) estimates the return to one extra year of full-time work for women at between 3 and 5 percent.

1.5.2 Model Fit

We now turn to presenting evidence on the within-sample fit of the model. The baseline dynamic model does a remarkable job of reproducing the profiles observed in the data. In this section we also look at how would the static version of the model (i.e., discount factor, $\beta = 0$, individual maximizes today's utility with no regard to the future. Therefore, the individual's choice reduces to static discrete choice.) would fare in trying to reproduce some important patterns. The same moments were used for the estimation of the static[34] and the dynamic baseline model.

Figure 1·4 depicts the fit of the models to the marriage choice proportions by education group. Each of the profiles implied by the estimated models has the right shape and matches the levels of the data closely. Table 1.6 demonstrates that the dynamic framework has no trouble generating the assortative mating profiles at first marriage. The baseline model's prediction follows the data very closely. The static model however over-predicts the proportion of those marrying down. In a static framework one is short-sighted and does not perceive the option value of waiting: a marriage is consented to as soon as a single agent meets a partner and marriage would imply a higher current period utility (versus lifetime expected utility) for both partners than remaining single. Hence, marriage is rather "more random" than preferential and the sorting patterns reflect more closely the education distribution in the population. For example, a college graduate female in both frameworks is more likely to meet a male with less than a college degree than a male with a post college degree. However, in the dynamic framework, the female perceives the option value of waiting for a better match and in some cases chooses to continue search.

[34] Parameter estimates are not presented here and are available upon request.

The dynamic model does a fine job of reproducing the married women's employment age profile for each education level, see Figure 1·5. The static model fails to capture the humped shape, most pronounced for some college and college graduate women, and tends systematically to under-predict early in life and over-predict later in life. This arises because in the static framework individuals do not have a strong incentive to participate when young to accumulate experience. The dip in employment reflects the impact of child-bearing on labor supply.

Most notably, in Table 1.7, the dynamic model replicates almost exactly the large disparities in married women's labor supply conditional on their educational attainment and their relative position in education. It slightly under-predicts the employment rate for high school graduates that are married up or equal. Focusing on the group with the most remarkable employment gap, college graduates, in the data we observe a 20 percentage points gap (50% vs. 79%) when comparing those married up and down. The dynamic model generates a gap of 18 percentage points (61% vs. 79%). The feature of the model that drives the higher labor market attachment of the married down women is the return to experience. Nevertheless, the static model provides a poor fit. While the model predictions capture the general pattern of response to husband's relative education, it under-predicts[35] the employment rate gap between married up and down, e.g., only 3 percentage points (74% vs. 77%) for the college graduates. In Figures 1·6-1·7, we show wage profiles by experience, gender and education. For women and for men, the trends and the levels are well fitted by both estimated model.

Overall, for the key moments, the baseline dynamic model fits the data remarkably

[35]Except for the HS graduates.

well. It also provides a much better fit to the data than the static version.

Table 1.8 provides additional assessment of the fit of the baseline model along various dimensions, for the four education groups. The results show a good match in terms of fertility rates. The dynamic model is also reproducing the differences in women's employment rates across marital status and the different fertility levels. Because children significantly increase the value of home production, the degree of specialization in home production is increasing as a function of the number of kids.

Table 1.9, confirms the evidence of selection on ability into marrying up, down and equal that are presented in Appendix D.4, using the NLSY79. More specifically, we find that for both genders, conditional on educational attainment, those that marry down (up) have lower (higher) AFQT average scores compared to those married equal. While these moments were not targeted in the estimation, the model generates ability moments and thus provides additional checks of the model. Table 1.9, panel A and B, report average ability by education and by relative position in education for women and men, respectively. Although we cannot compare these ability moments to AFQT moments from the data, it is reassuring that the mechanism in the model duplicates the feature observed in the data.

1.6 Counterfactuals

1.6.1 Returns to Experience

As discussed earlier, we consider wage returns to experience and its dynamic effects as strong candidates for explaining the gap in labor supply observed among married women across the three categories of husband's relative education. We now turn to assess the magnitude of the effects of wage growth (wage returns to experience). While its difficult

to make an assessment using reduced forms techniques, our model allows us to construct counterfactual profiles, by comparing profiles with and without returns to experience for women (i.e., a female's life-cycle wage profile is flat conditional on her educational level). We compare outcomes from the simulation assuming that experience does not lead to any wage growth for females, i.e., $\varphi_{2W} = \varphi_{3W} = 0$, with the baseline outcomes predicted by the dynamic model given the estimated parameters. Hence, the differences in behavioral outcomes should be accounted for by the lack of returns to experience.

The simulation results are reported in Figures 1·8-1·9 and Tables 1.10-1.11. Without the prospect of wage growth, the marriage market is affected. It takes longer for women from all education groups to marry (Figure 1·8). The consequence of this on the level of marriage rate by the age of 45 is minor, except for those holding a post-graduate degree. In the model, this arises from higher rejection rate from the men's part. Because lifetime expected value from working is lower and women's labor force attachment will be lower, men opt for waiting for a female with a higher lifetime value from working. Indeed, the model predicts higher rates of marrying down, especially for college and post-college graduate females (Table 1.10). It is most clear for the post-graduate females: holding everything else constant, with a lower value from working, females are "less" attractive to men from their own group yet still desired but those with less than a post graduate degree, the marriage rate will be lower and more women will marry down.

In Figure 1·9, the profiles reflect the lower labor market attachment arising from the lack of incentive to invest in human capital accumulation when young in the absence of wage growth. We also note that lower-educated women respond to the absence of returns to experience to a greater extent. The simple reason is that low-educated workers are

more likely to be on the margin of the employment decision than high skilled workers, and therefore are more responsive to changes in the incentives to work.[36]

The effect of experience is also very important for understanding the employment rate gap within the same education group across the three marriage categories. The model without wage growth still predicts an employment gap between the married up group and the married down group, yet more modest (Table 1.11): 3.5% vs. 5.4% for HS graduate, 4.2% vs. 12.1% for some college, 8.6% vs. 18% for college graduate, and 3.1% vs. 11.4% for post-graduate (gap between equal and down). The return to experience explains 52% of the gap between the group that is married up and down. Married down women have the incentive to work more given the lower earning husbands. Everything else equal, a female that is married down experiences a smaller wage differential between her and her husband, making her more likely to work than the females experiencing larger wage differentials, those with equally or higher educated husbands. However, given the flat wage profile, the opportunity cost of not participating or leaving the job market is much lower. Then, when the married down female's husband is hit with a positive wage spell, she is more likely to decide to not participate since she does not perceive higher forgone earnings compared to if she were to participate and accumulate experience.

1.6.2 Divorce

Divorce has been shown to matter for a variety of outcomes. Fernandez and Wong (2011) find that the higher probability of divorce faced by the younger cohorts of women is able to explain a large proportion of the observed increase in female labor force participation,

[36]These predictions are in line with the empirical analysis of Juhn et al. (1991, 2002). They provide estimates of the elasticity of LS by skill group that confirm that low-skilled LS is much more elastic than high-skilled workers.

compared to the older cohorts.[37] To assess the importance of divorce as a driver for female labor force participation, we perform a counterfactual simulation assuming no divorce[38] and compare with the baseline results.

Because of the higher "spousal insurance" married women face in the absence of divorce, the incentive to work and accumulate experience as a form of self-insurance is lower. Indeed, figure 1·10 exhibits lower employment rates over the life-cycle. The magnitude of the increase for the less educated (HS graduates and some college) in more pronounced than that for the college and post-college graduates. This reflects the fact that the latter groups face lower divorce rates than the former (see Table A.8) and therefore would be less affected by changes in the divorce risk. Turning to the employment rates for women that marry up and down, the counterfactual predicts significantly lower overall difference between the two groups: the mean difference under no divorce is 11.5 percentage points compared to 5.5 percentage points in the baseline model. The results therefore suggest that divorce plays a role in the employment rate gap observed between married up and down.

1.6.3 Schooling Distribution

The model is estimated based on data for the 1965 cohort from the NLSY79. One of the key forces driving the decision to marry is the education distribution of potential wives and husbands, which are determined outside the model. We substitute the schooling distributions for 1965 cohort with the one of 1945, keeping all parameters fixed at the estimated

[37] See also Stevenson (2008) and Voena (2011) for the relationship between divorce and female labor force participation.

[38] One should approach this exercise with precaution. When divorce is not allowed, bargaining weight within the couple remains constant over the course of marriage and is not re-negotiated.

values. Any differences in behavioral outcomes are attributable to this modification.

Table 1.12 presents the prediction of the sorting profile. Since the education gender gap in the population is larger for the 1945 cohort, women are less likely to marry down, overall from 33 percent to 21 percent, while the homogamy rate is largely unaffected - the data exhibits the same pattern (see Figure 1·1). Note that the employment profiles for women married up, equal and down are unchanged (see Table 1.13). The striking differences in labor supply behaviors along with lower proportion of married down women translate into lower employment profiles compared to the baseline cohort (see Figure 1·11). Put differently, the changes in the education distribution predicted a 12 percentage points increase in the proportion of married down women (21% to 33%) while homogamy rates stay constant, and an overall increase of 6.8 percentage points in employment rates for married women aged 30-40. In the data, the employment rate increased by roughly 10 percentage points for the same age group between the 1945 and 1965 cohorts. Furthermore, the associated change in the proportion of women marrying down, in isolation, is able to account for 2.5 out of the 6.8 percentage points difference. Marriage sorting patterns have life-cycle consequences and are critical to the understanding of female labor supply.

1.7 Conclusion

In this paper, we show that a spouse's relative educational attainment produces dynamic labor supply effects on married women. Our reduced form results suggested that if a woman's educational attainment is higher than that of her husband, her likelihood of being employed is associated with an up to 14.5 percentage points higher employment rate compared to when her educational attainment is lower than that of her husband.

We have formulated a dynamic model of endogenous marriage and labor supply decisions in a collective framework. Both the dynamic as well as the static version of our model were structurally estimated using data from the NLSY79. The results indicate that there are substantial dynamic effects. While the dynamic model captures reasonably well the key profiles of labor supply, and marriage decisions displayed by the data, the static model provide a poor goodness of fit. The estimates were then used to gauge the importance of wage growth on the labor supply behavior of women in the three marriage categories (marrying up, equal, or down). In particular, we find that when wage returns to experience are ruled out in the estimated model and everything else is kept equal, the predicted employment gap between those married up and down drops substantially. Returns to experience alone account for 52 percent of the employment gap.

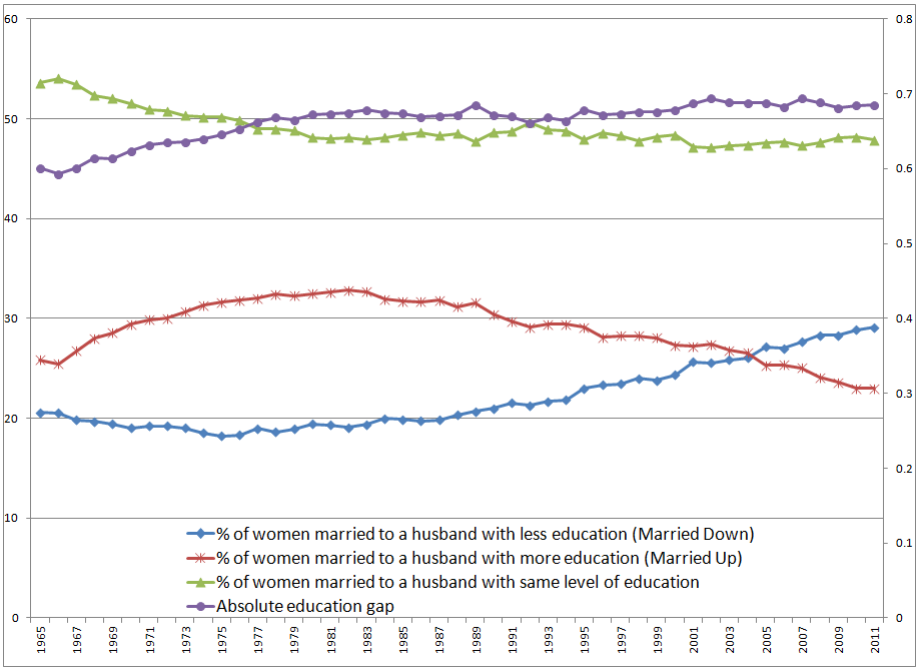
In an alternative exercise, the findings suggest that the changing assortative mating patterns over time are important drivers of the increase in married women's LFP. Overlooking the latter leads to an overestimation of the effects of other factors shaping women's labor supply examined in the empirical literature, such as the changing wage structure (see Jones et al., 2003), the improvement in home technology (see Greenwood et al., 2012), or the changing culture (see Fernandez, 2007), to name a few.

While previous research on the female labor supply emphasized the importance of returns to experience, this paper points to the importance of husband's relative education within couples and wage returns to experience in creating dynamic labor supply effects. The model makes a significant contribution to this area of research and includes important features, while opening further lines of inquiry. One important extension can be the examination of the effects of spouse's relative education on savings and asset accumulation

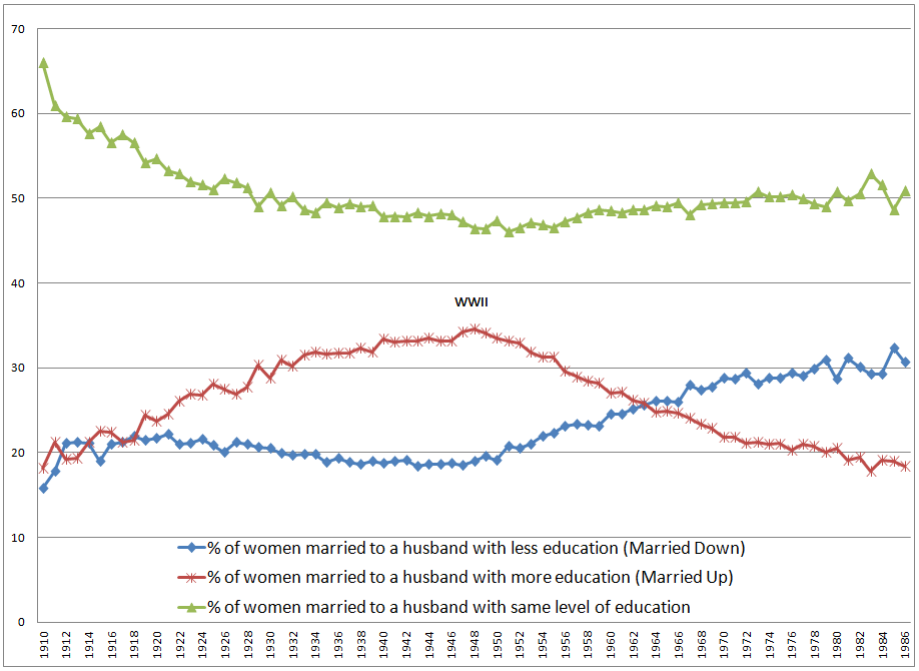
dynamics in a framework including income tax policies. Also, recent models have emphasized that investment in education generates returns in the marriage market (Chiappori et al., 2009; Ge, 2011). In the future, it may also be important to endogenize the education decision.

Figure 1·1: Marriage Patterns

(a) Cross Sectional



(b) Birth Cohorts

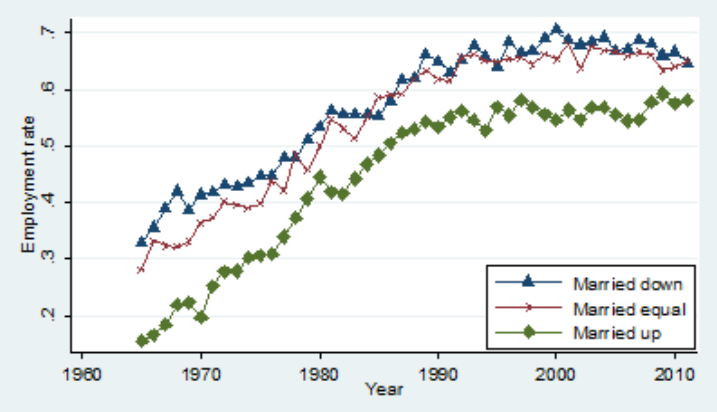


Source - March CPS 1965 - 2011.

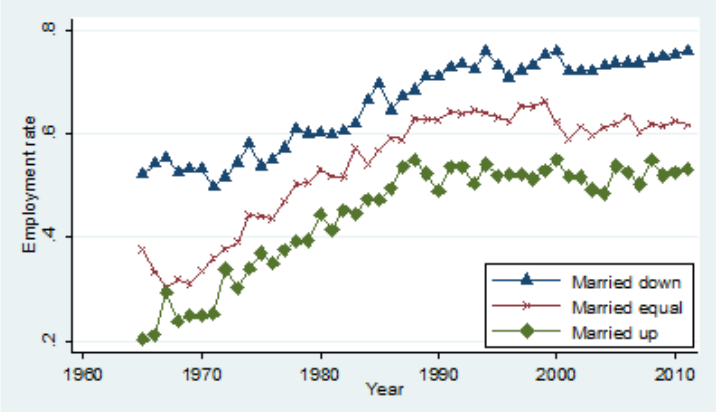
Notes - Married white women, ages 25 - 55.

Figure 1·2: Employment Rate by Wives' Education and Match

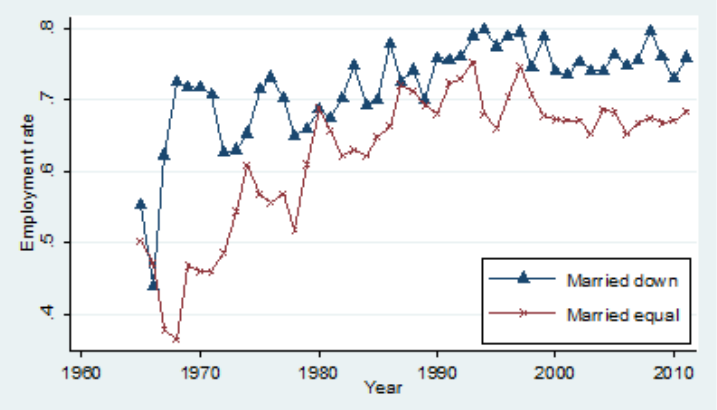
(a) Some College



(b) College Graduate



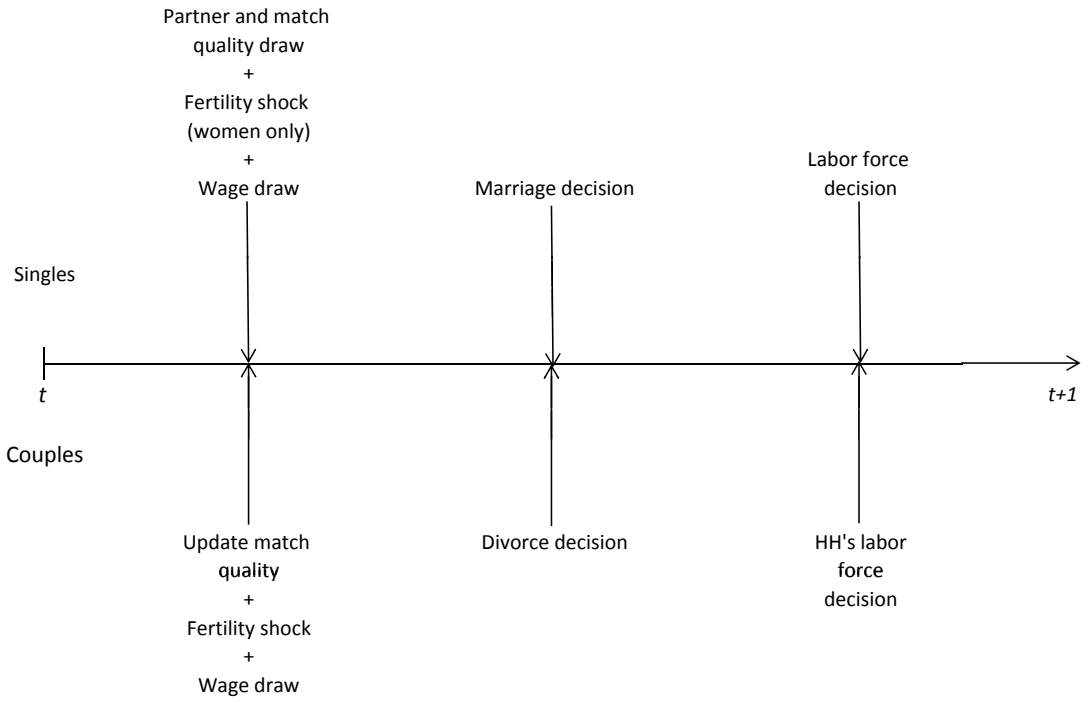
(c) Post-Graduate



Source - March CPS 1965 - 2011.

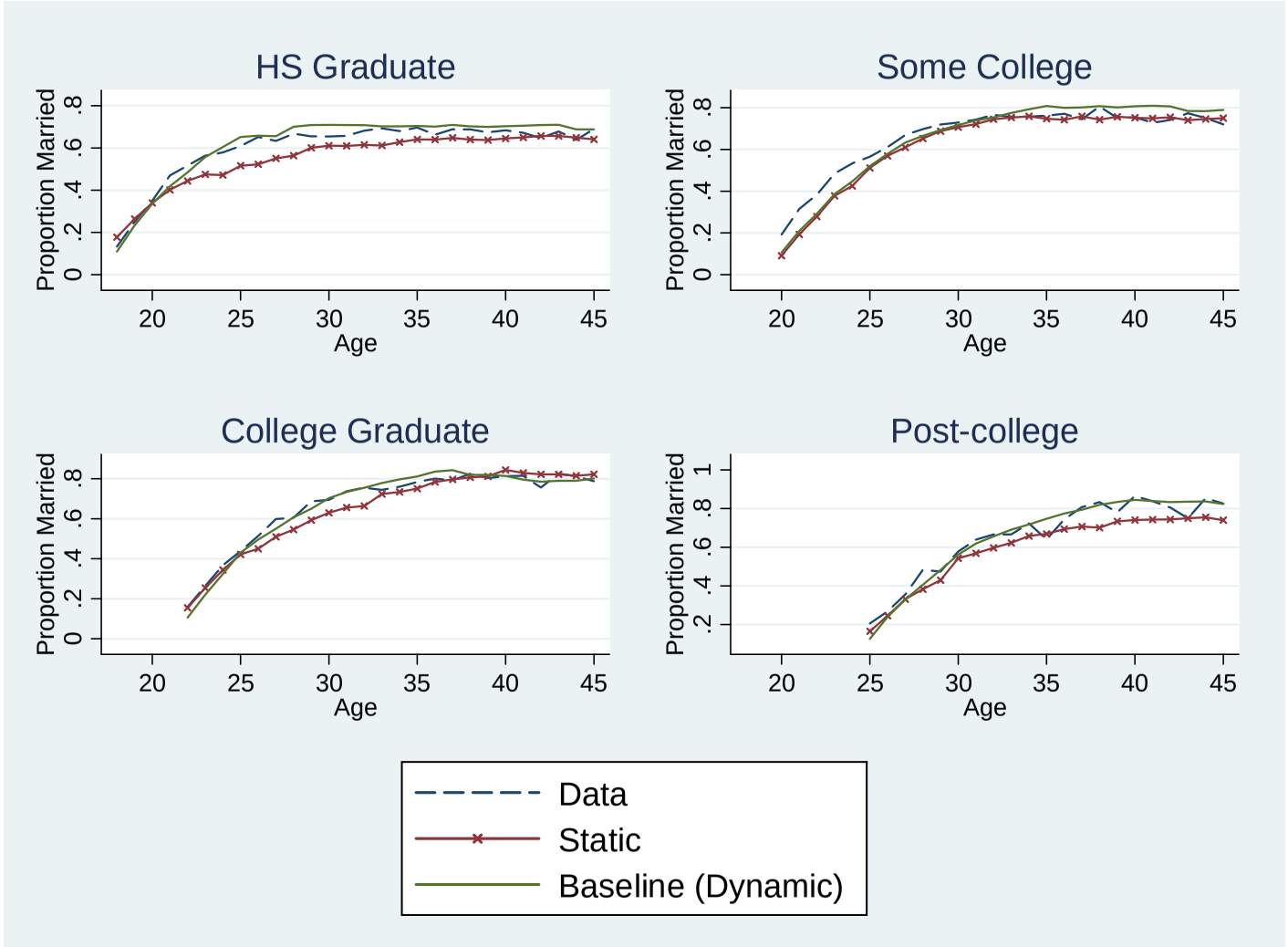
Notes - Married white women, ages 25 - 55. Proportion working at least 20 weekly hours.

Figure 1·3: Timing of Shocks and Decisions



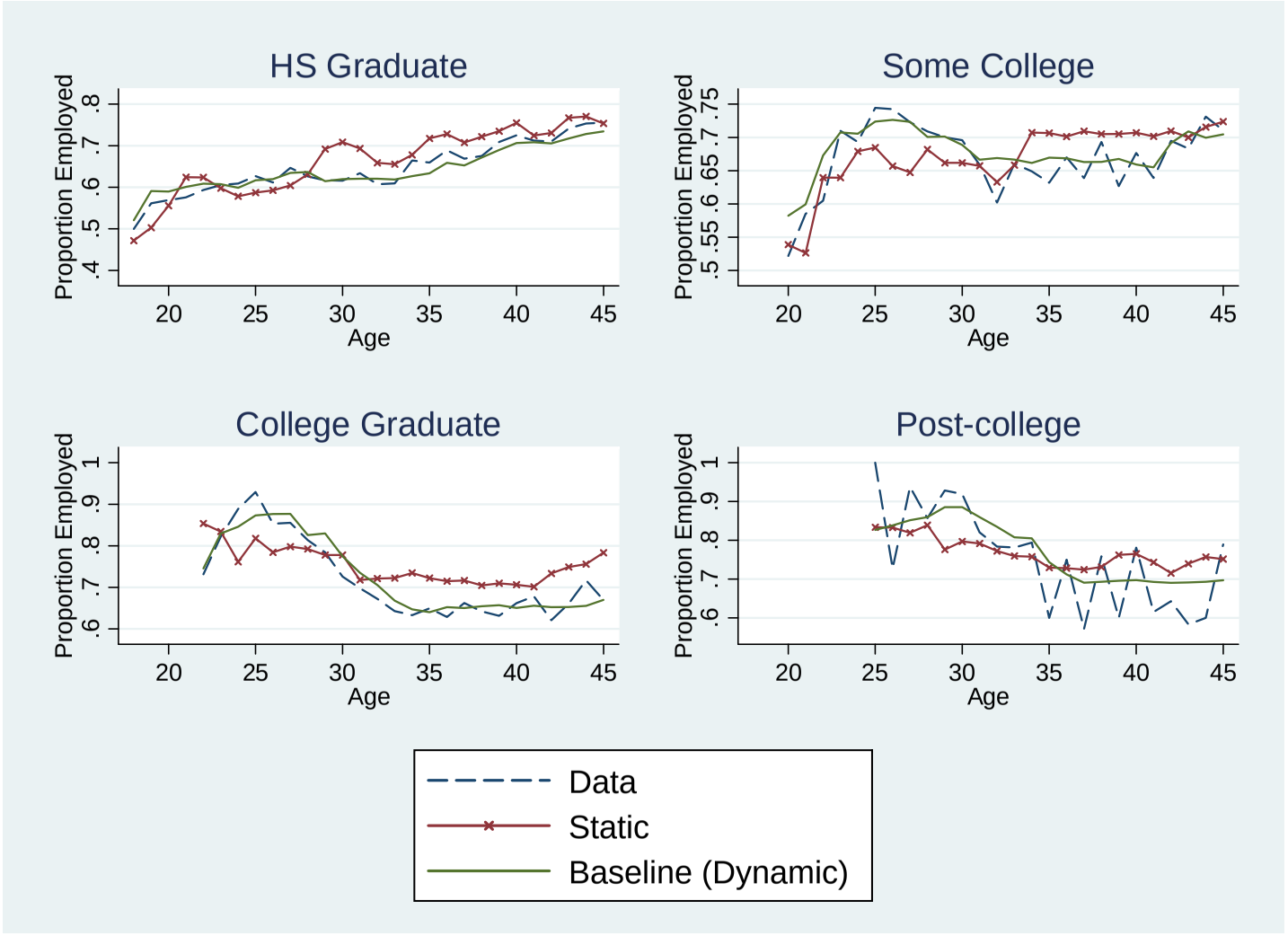
Notes -

Figure 1·4: Fit of Marriage Rates by Education



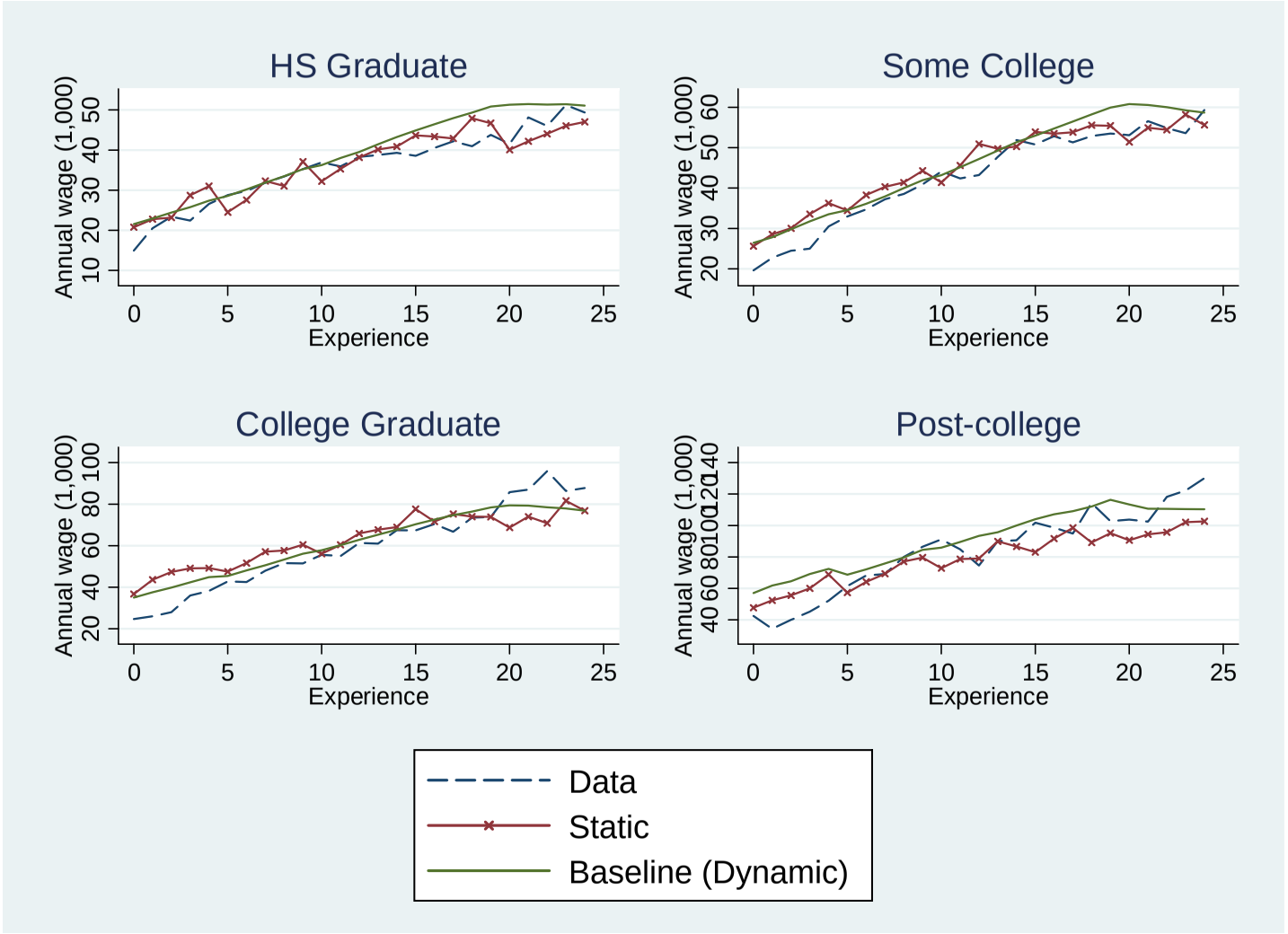
Notes -

Figure 1·5: Fit of Employment Rates - Married Women by Education



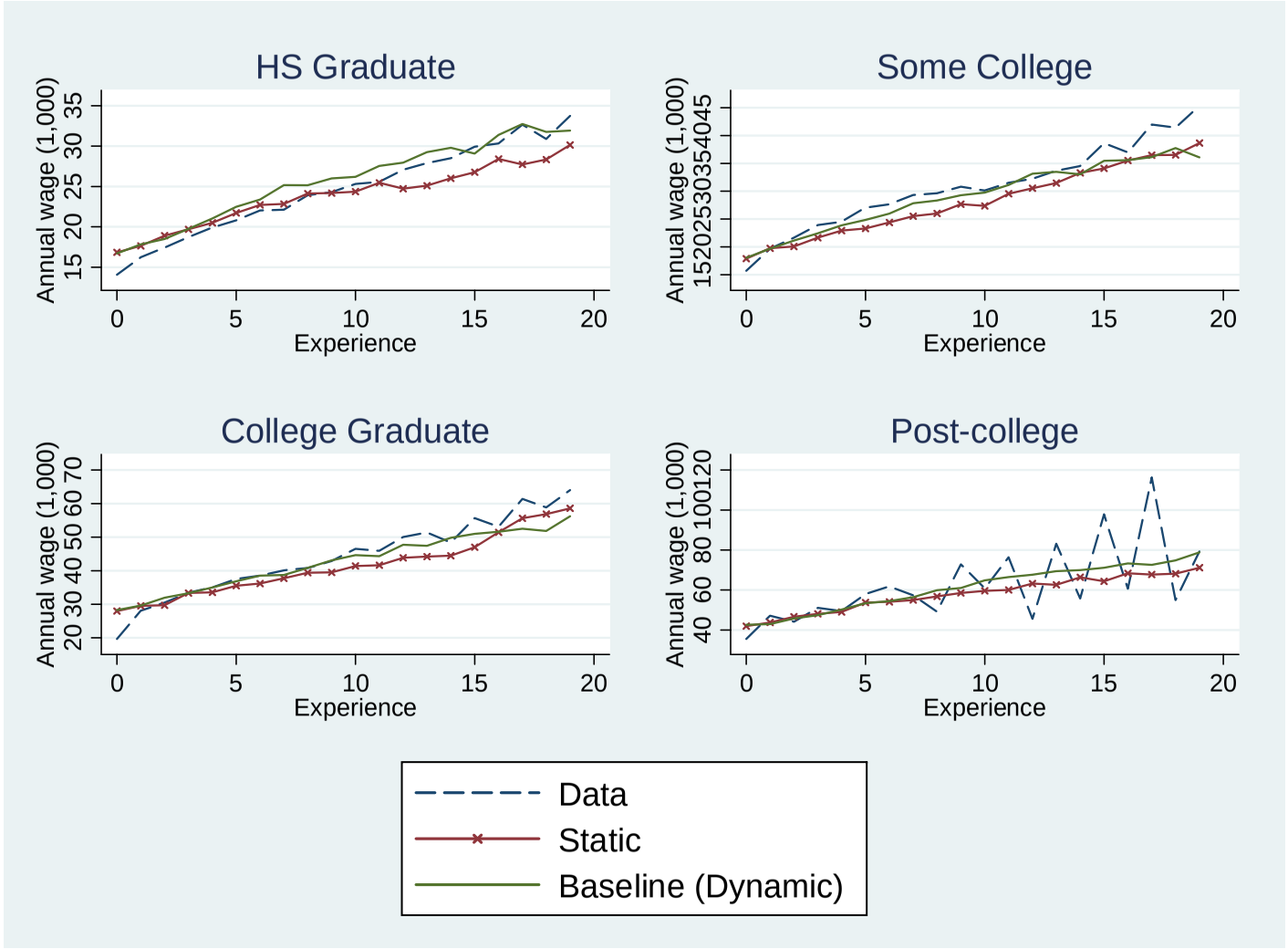
Notes -

Figure 1·6: Fit of Earnings by Education - Men



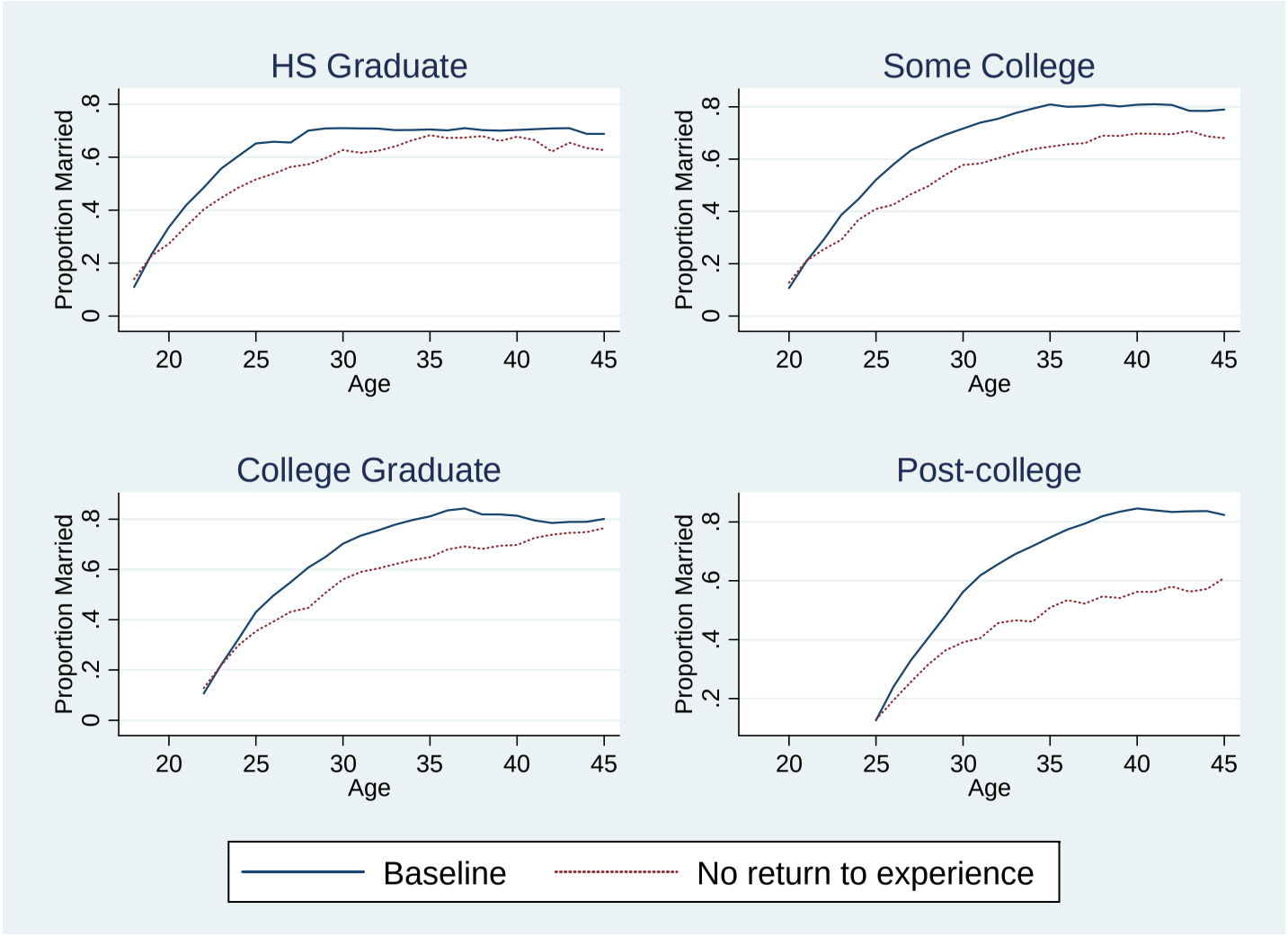
Notes -

Figure 1·7: Fit of Earnings by Education - Women



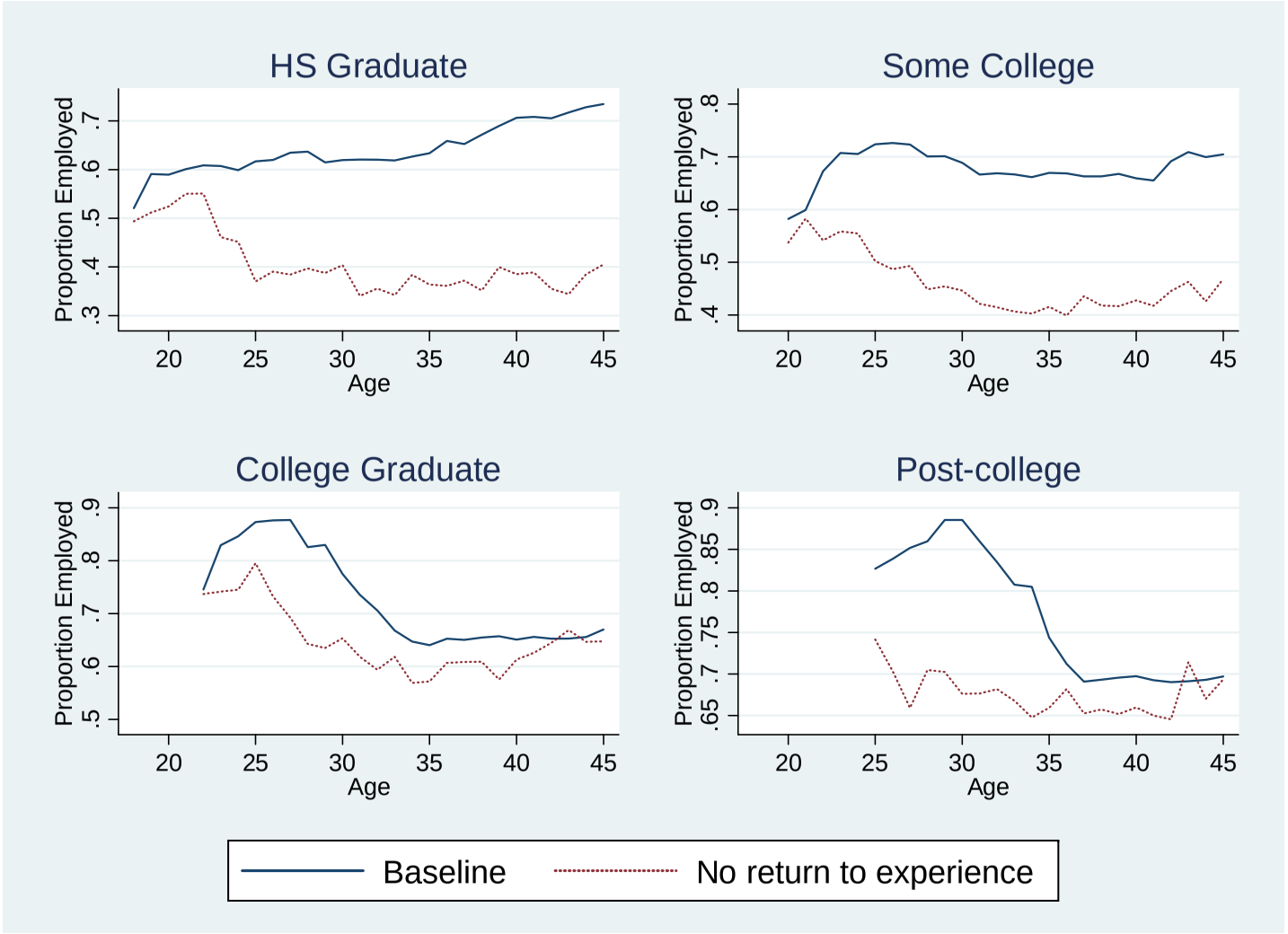
Notes -

Figure 1·8: Women Marriage Rate - Baseline and No Returns to Experience



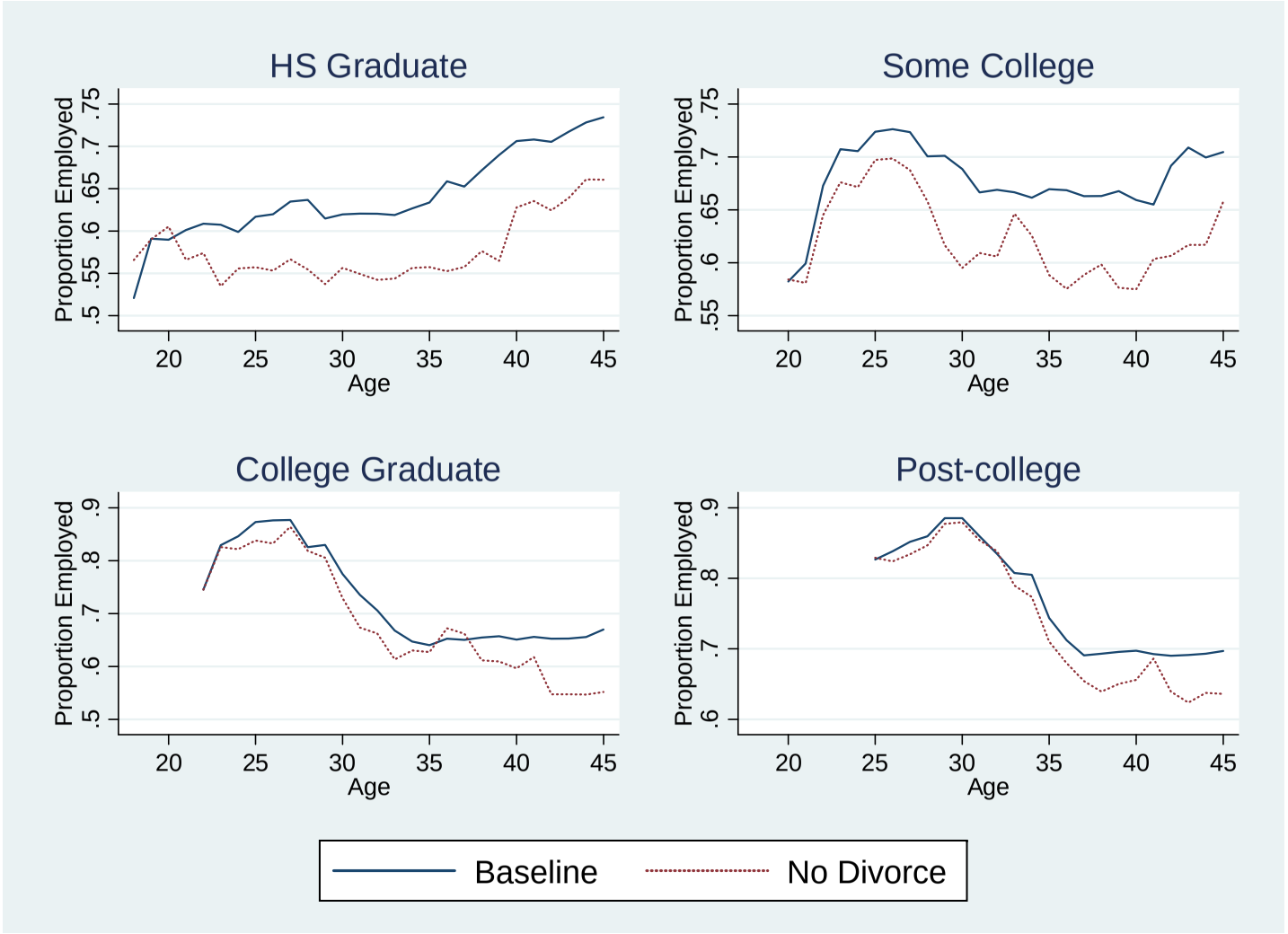
Notes -

Figure 1·9: Married Women Employment Rate - Baseline and No Returns to Experience



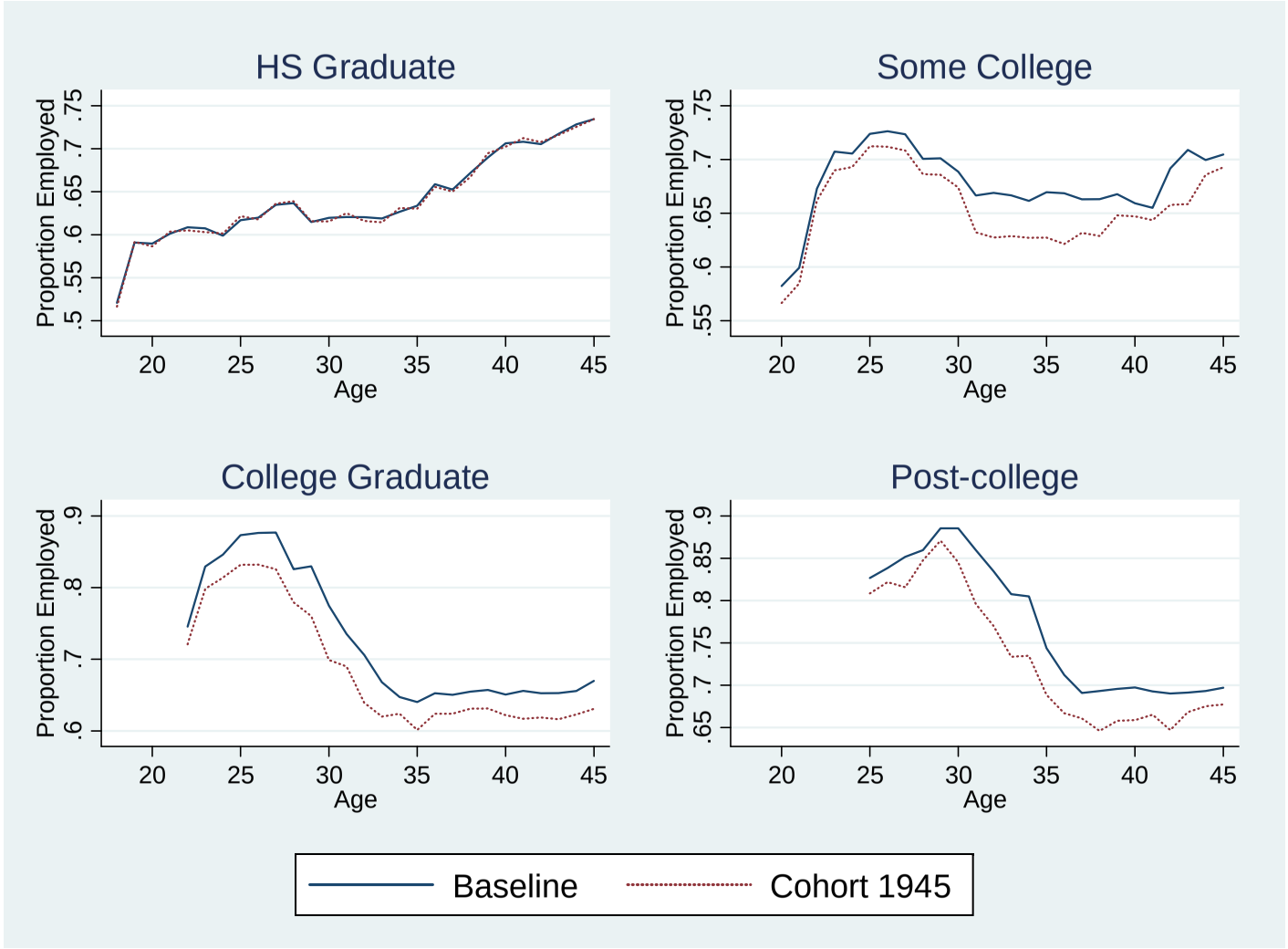
Notes -

Figure 1·10: Married Women Employment Rate - Baseline and No Divorce



Notes -

Figure 1·11: Married Women Employment Rate - Baseline and Cohort 1945



Notes -

Table 1.1: Husbands' Education Distribution by Wive's Educational Attainment

	(1) All sample				
Men Education Group	Women Education Group				
	HSD	HSG	SC	CG	PC
High School Dropout (HSD)	65.32	17.27	5.9	1.87	1.05
High School Graduate (HS)	25.49	50.36	25.57	12.15	7.82
Some College (SC)	7.13	20.43	38.27	19.36	13.85
College Graduate (CG)	1.64	9.2	21.38	43.57	29.29
Post College Degree (PC)	0.42	2.74	8.88	23.05	48
% Women Married Down	0	17.27	31.47	33.38	52

	(2) 40-45 cohorts				
Men Education Group	Women Education Group				
	HSD	HSG	SC	CG	PC
High School Dropout (HSD)	59.87	17.82	5.98	1.91	1.45
High School Graduate (HS)	30.57	50.1	23.48	9.9	6.31
Some College (SC)	7.58	20.1	33.33	14.62	11.84
College Graduate (CG)	1.59	9.1	24.61	41.88	21.38
Post College Degree (PC)	0.38	2.88	12.59	31.69	59.03
% Women Married Down	0	17.82	29.46	26.43	40.97

	(3) 60-65 cohorts				
Men Education Group	Women Education Group				
	HSD	HSG	SC	CG	PC
High School Dropout (HSD)	59.53	11.44	4.85	1.42	0.74
High School Graduate (HS)	28.6	56.05	28.56	13.42	8.67
Some College (SC)	9.15	21.64	41	20.78	14.82
College Graduate (CG)	2.29	8.76	18.99	44.54	31.22
Post College Degree (PC)	0.43	2.11	6.6	19.84	44.55
% Women Married Down	0	11.44	33.41	35.62	55.45

Source - March CPS 1965 - 2011.

Notes - Married white women, ages 25 - 55.

Table 1.2: Women's Employment Rate by Wives' and Husband's Educational Attainment

Men Education Group	Women Education Group HSG	SC	CG	PC
High School Dropout (HSD)	**49**	**57.47**	**68.07**	**71.24**
High School Graduate (HS)	51.92	**62.18**	**71.58**	**80.47**
Some College (SC)	51.47	60.23	**68.39**	**79.97**
College Graduate (CG)	44.87	49.74	57.78	**71.61**
Post College Degree (PC)	41.17	44.38	47.76	66.31

Source - March CPS 1965 - 2011.
Notes - Married white women, ages 25 - 55. Proportion working at least 20 weekly hours. * - small sample size. In bold: women marrying down.

Table 1.3: Estimated Effects on Wife's Employment

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Female married down (d)	**0.050*** **	**0.049*** **	**0.036*** **	**0.042*** **	**0.038*** **	**0.037*** **
	(0.001)	**(0.001)**	**(0.002)**	**(0.002)**	**(0.003)**	**(0.003)**
Female married up (d)	**-0.049*** **	**-0.047*** **	**-0.029*** **	**-0.025*** **	**-0.022*** **	**-0.023*** **
	(0.001)	**(0.001)**	**(0.001)**	**(0.002)**	**(0.002)**	**(0.003)**
Female post graduate (d)	0.254***	0.249***	0.299***	0.278***	0.306***	0.293***
	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.006)
Female college graduate (d)	0.191***	0.182***	0.230***	0.195***	0.225***	0.204***
	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.006)
Female some college (d)	0.181***	0.165***	0.201***	0.152***	0.177***	0.162***
	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.005)
Female high school graduate (d)	0.145***	0.123***	0.145***	0.102***	0.120***	0.111***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)
Age	0.003***	-0.004***	-0.003***	-0.004***	-0.003***	-0.003*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Age gap	-0.001***	-0.002***	-0.001***	-0.002***	-0.001***	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of children in the HH		-0.043***	-0.041***	-0.042***	-0.038***	-0.043*
		(0.000)	(0.000)	(0.000)	(0.000)	(0.025)
Presence of a child 0-6		-0.221***	-0.224***	-0.221***	-0.226***	-0.233***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Male post graduate (d)				-0.038***	0.029***	0.029***
				(0.007)	(0.007)	(0.008)
Male college graduate (d)				0.010*	0.062***	0.059***
				(0.005)	(0.005)	(0.006)
Male some college (d)				0.076***	0.098***	0.096***
				(0.004)	(0.004)	(0.005)
Male high school graduate (d)				0.051***	0.061***	0.059***
				(0.003)	(0.003)	(0.004)
Dummies for the deciles of Husband's annual income	NO	NO	YES	NO	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
MSA fixed effects	NO	NO	NO	NO	NO	YES
Mean employment (dependent variable)	0.519	0.519	0.519	0.519	0.519	0.512
Observations	972,821	972,821	972,821	972,821	972,821	681,503

Notes - Married white women, ages 25 - 55. Employment indicator is one when working at least 20 weekly hours. Marginal effects (instead of logit coefficients) are reported. *** p<0.01, ** p<0.05, * p<0.1. (d) for dummy variable. Reference education group: HSD.

Table 1.4: Women Employment Rate by Women and Men Education Group

(1) Husband at the top 10% of income distribution					(2) Husband at median income (45-55% of income distribution)				
	Women Education Group					Women Education Group			
Men Education Group	HSG	SC	CG	PC	Men Education Group	HSG	SC	CG	PC
High School Dropout (HSD)	**34.99**	**40.64**	**63.19**	**60**	HSD	**54.28**	**63.64**	**68.85**	**75.38**
High School Graduate (HS)	37.11	**46.05**	**52.43**	**70.24**	HSG	59.86	**68.66**	**78.25**	**83.61**
Some College (SC)	36.55	44.88	**53.24**	**65.35**	SC	59.95	68.43	**75.26**	**83.36**
College Graduate (CG)	32.81	35.86	42.68	**59.44**	CG	60.17	62.06	71.1	**80.32**
Post College Degree (PC)	33.2	36.02	39.18	58.33	PC	48.33	54.22	56.86	73.52

Source - March CPS 1965 - 2011.
Notes - Married white women, ages 25 - 55. Proportion working at least 20 weekly hours. In bold: women marrying down.

Table 1.5: Estimated Effects by Education Group (Dependent Variable: Employment)

VARIABLES	(1) High School Graduate	(2) Some Graduate	(3) College Graduate	(4) Post-Graduate
Female married down (d)	-0.032***	0.009***	0.085***	0.059***
	(0.004)	(0.004)	(0.004)	(0.005)
Female married up (d)	-0.005**	-0.075***	-0.063***	
	(0.002)	(0.003)	(0.004)	
Dummies for the deciles of Husband's annual income	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES
MSA fixed effects	YES	YES	YES	YES
Mean employment (dependent variable)	0.477	0.574	0.594	0.691
Observations	324,168	147,670	112,336	52,429

Notes - Married white women, ages 25 - 55. Employment indicator is one when working at least 20 weekly hours. Marginal effects (instead of logit coefficients) are reported. All models include own age, age gap, number of children in the HH and an indicator for the presence of a child 0-6. *** p<0.01, ** p<0.05, * p<0.1.

Table 1.6: Assortative mating at the First Marriage - Data, Baseline and Static Model

Woman's Education	**Data**	**Baseline Dynamic Model**	**Static Model**
HS Graduate			
Up	0.264	0.261	0.236
Equal	0.586	0.585	0.523
Down	0.150	0.154	0.242
Some College			
Up	0.277	0.220	0.174
Equal	0.288	0.310	0.306
Down	0.434	0.471	0.519
College Graduate			
Up	0.168	0.162	0.115
Equal	0.465	0.463	0.324
Down	0.367	0.375	0.561
Post-college			
Up	-	-	-
Equal	0.407	0.407	0.254
Down	0.593	0.593	0.746

Table 1.7: Married Women's Employment by Relative Position in Education - Data, Baseline and Static Model

Woman's Education	**Data**	**Baseline Dynamic Model**	**Static Model**
HS Graduate			
Up	0.636	0.608	0.642
Equal	0.640	0.626	0.644
Down	0.660	0.662	0.669
Some College			
Up	0.609	0.609	0.653
Equal	0.672	0.658	0.693
Down	0.732	0.730	0.710
College Graduate			
Up	0.590	0.611	0.743
Equal	0.738	0.726	0.759
Down	0.795	0.791	0.773
Post-college			
Up	-	-	-
Equal	0.678	0.703	0.749
Down	0.813	0.817	0.809

Table 1.8: Selected Moments - Data and Baseline Model

	Data				Model			
	HS Graduate	**Some College**	**College Graduate**	**Post College**	**HS Graduate**	**Some College**	**College Graduate**	**Post College**
No. of kids by 40	1.90	1.82	1.73	1.42	1.82	1.85	1.84	1.45
Married with								
0 children	0.82	0.83	0.91	0.89	0.90	0.88	0.91	0.90
1 child	0.64	0.68	0.77	0.75	0.70	0.70	0.74	0.81
2 children	0.58	0.61	0.60	0.61	0.58	0.58	0.64	0.74
3 children	0.47	0.57	0.49	0.48	0.48	0.53	0.49	0.52
4+ children	0.46	0.36	0.35	0.47	0.43	0.40	0.39	0.50
Single with								
No Child	0.80	0.80	0.88	0.87	0.75	0.81	0.86	0.87
Child	0.64	0.77	0.90	1.00	0.67	0.81	0.89	0.94

Notes - Due to the small sample size of single women, we assumed that the fertility effect can be adequately captured by the presence of any children.

Table 1.9: Ability and Match Quality by Match

Panel A: Average Ability of Wives

Wife's Education	Relative Position **Up**	**Equal**	**Down**
HS Graduate	2.32	0.36	-2.06
Some College	5.36	-0.79	-1.62
College Graduate	2.60	-0.05	-2.49
Post-college	-	2.30	-1.06

Panel B: Average Ability of Husbands

Husband's Education	Relative Position **Up**	**Equal**	**Down**
HS Graduate	1.63	-2.35	-
Some College	4.66	-2.21	-3.24
College Graduate	3.49	1.04	-3.28
Post-college	-	-0.51	-2.60

Table 1.10: Assortative mating at the First Marriage - Baseline and No Return to Experience

Woman's Education	**Baseline Dynamic Model**	**No Return to Experience**
HS Graduate		
Up	0.261	0.259
Equal	0.585	0.537
Down	0.154	0.204
Some College		
Up	0.220	0.195
Equal	0.310	0.323
Down	0.471	0.482
College Graduate		
Up	0.162	0.126
Equal	0.463	0.366
Down	0.375	0.508
Post-college		
Up	-	-
Equal	0.407	0.240
Down	0.593	0.760

Table 1.11: Married Women's Employment by Relative Position in Education - Baseline and No Return to Experience

Woman's Education	**Baseline Dynamic Model**	**No Return to Experience**
HS Graduate		
Up	0.608	0.395
Equal	0.626	0.402
Down	0.662	0.430
Some College		
Up	0.609	0.416
Equal	0.658	0.457
Down	0.730	0.458
College Graduate		
Up	0.611	0.565
Equal	0.726	0.589
Down	0.791	0.652
Post-college		
Up	-	-
Equal	0.703	0.651
Down	0.817	0.682

Table 1.12: Assortative mating at the First Marriage - Baseline and Cohort 1945

Woman's Education	**Baseline Dynamic Model**	**Cohort Return 1945**
HS Graduate		
Up	0.261	0.346
Equal	0.585	0.547
Down	0.154	0.107
Some College		
Up	0.220	0.263
Equal	0.310	0.323
Down	0.471	0.414
College Graduate		
Up	0.162	0.258
Equal	0.463	0.481
Down	0.375	0.261
Post-college		
Up	-	
Equal	0.407	0.513
Down	0.593	0.487

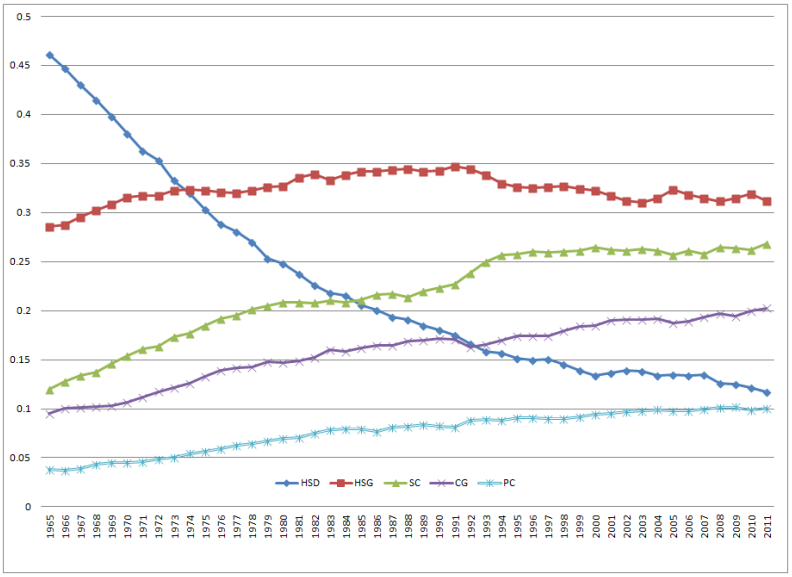
Table 1.13: Married Women's Employment by Relative Position in Education - Baseline and Cohort 1945

Woman's Education	**Baseline Dynamic Model**	**Cohort Return 1945**
HS Graduate		
Up	0.608	0.607
Equal	0.626	0.622
Down	0.662	0.664
Some College		
Up	0.609	0.612
Equal	0.658	0.654
Down	0.730	0.728
College Graduate		
Up	0.611	0.612
Equal	0.726	0.728
Down	0.791	0.787
Post-college		
Up	-	
Equal	0.703	0.701
Down	0.817	0.819

Appendices

A.1 Additional Figures and Tables

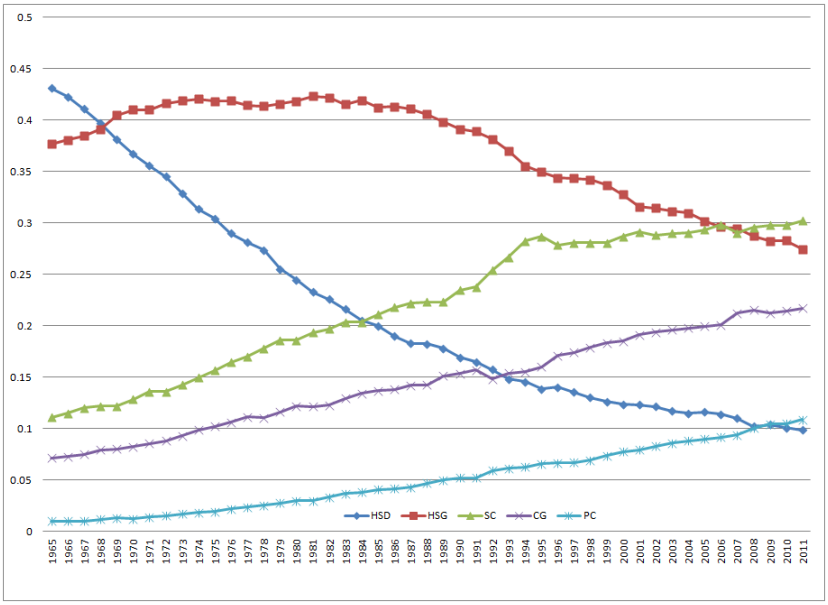
Figure A.1: Men's Educational Attainment



Source - March CPS 1965 - 2011.

Notes - Ages 22 - 65.

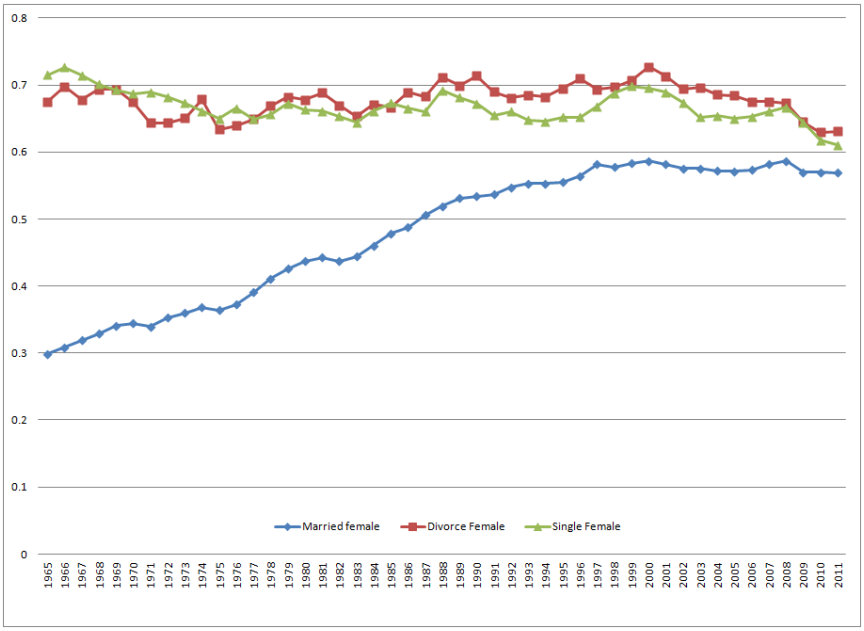
Figure A.2: Women's Educational Attainment



Source - March CPS 1965 - 2011.

Notes - Ages 22 - 65.

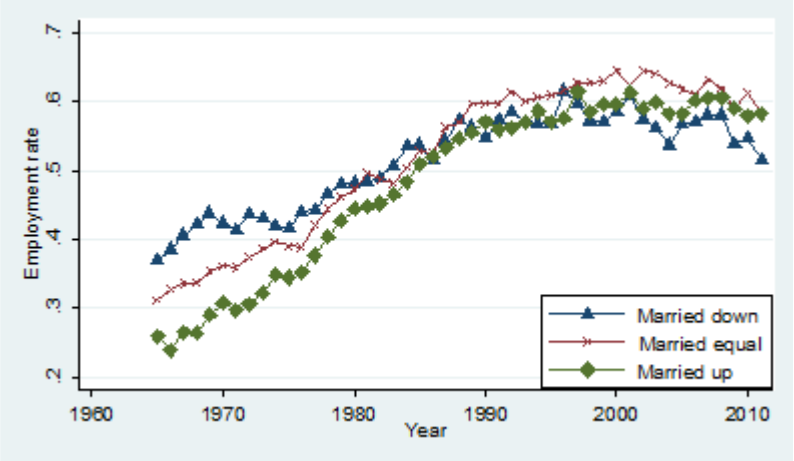
Figure A.3: Female's Employment Rate by Marital Status



Source - March CPS 1965 - 2011.

Notes - White females, ages 22 - 65. Proportion working at least 20 weekly hours.

Figure A.4: Married HS Graduate Female's Employment Rate by Match



Source - March CPS 1965 - 2011.

Notes - White females, ages 25 - 55. Proportion working at least 20 weekly hours.

Table A.1: Men's Employment by Women and Men Education Group

	Men Education Group			
Women Education Group	HSG	SC	CG	PC
High School Dropout (HSD)	**84.63**	**84.12**	**87.52**	**87.34**
High School Graduate (HS)	87.8	**88.93**	**92.51**	**92.97**
Some College (SC)	87.29	89.06	**92.78**	**93.34**
College Graduate (CG)	88.48	88.54	92.28	**93.2**
Post College Degree (PC)	85.8	85.88	89.54	92.02

Notes - * - small sample size. Proportion working at least 20 weekly hours. In bold: men marrying down.

Table A.2: Women's Employment Rate by Women and Men Education Group

(1)

Husband between the 80-90% of income distribution

	Women Education Group			
Men Education Group	HSG	SC	CG	PC
High School Dropout (HSD)	**38.53**	**52.33**	**66.83**	**65.52**
High School Graduate (HS)	43.88	**54.32**	**65.97**	**79.09**
Some College (SC)	46.14	55.44	**63.16**	**78.8**
College Graduate (CG)	41.64	49.61	57.3	**70.79**
Post College Degree (PC)	44.86	49.7	52.77	70.4

(2)

Husband between the 70-80% of income distribution

	Women Education Group			
Men Education Group	HSG	SC	CG	PC
High School Dropout (HSD)	**44.69**	**58.33**	**66.39**	**84.78**
High School Graduate (HS)	50.73	**61.32**	**72.02**	**80.59**
Some College (SC)	51.46	61.49	**68.26**	**80.74**
College Graduate (CG)	49.54	56.56	64.06	**75.83**
Post College Degree (PC)	52	54.11	58.99	72.86

(3)

Husband between the 60-70% of income distribution

	Women Education Group			
Men Education Group	HSG	SC	CG	PC
High School Dropout (HSD)	**48.87**	**57.01**	**68.42**	**66.67**
High School Graduate (HS)	54.82	**65.86**	**74.38**	**83.39**
Some College (SC)	55.89	64.76	**73.14**	**82.72**
College Graduate (CG)	52.36	58.43	68.14	**80.01**
Post College Degree (PC)	50.07	56.64	60.39	74.55

(4)

Husband between the 50-60% of income distribution

	Women Education Group			
Men Education Group	HSG	SC	CG	PC
High School Dropout (HSD)	**52.74**	**61.89**	**66.77**	**72.06**
High School Graduate (HS)	58.66	**68.56**	**77.42**	**86.06**
Some College (SC)	59.69	67.09	**75.07**	**84.94**
College Graduate (CG)	58.65	61.6	71.25	**80.63**
Post College Degree (PC)	53.61	54.92	57.83	74.64

(5)

Husband between the 40-50% of income distribution

	Women Education Group			
Men Education Group	HSG	SC	CG	PC
HSD	**55.83**	**62.62**	**71.25**	**75.71**
HSG	59.52	**67.67**	**77.81**	**84.65**
SC	59.84	68.43	**76.04**	**83.39**
CG	58.36	62.94	70.25	**81.18**
PC	51.94	51.85	56.51	72.49

(6)

Husband between the 30-40% of income distribution

	Women Education Group			
Men Education Group	HSG	SC	CG	PC
HSD	**53.85**	**58.59**	**71.47**	**72.46**
HSG	57.26	**65.65**	**75.84**	**81**
SC	58.49	64.63	**75.39**	**83.04**
CG	56.72	58.8	66.78	**80.5**
PC	54.3	53.86	57.38	72.94

(7)

Husband between the 20-30% of income distribution

	Women Education Group			
Men Education Group	HSG	SC	CG	PC
HSD	**48.48**	**53.5**	**73.33**	**90.48**
HSG	51.61	**63.44**	**74.86**	**87.34**
SC	55.98	60.27	**73.14**	**80.45**
CG	57.31	58.2	63.41	**81.86**
PC	46.46	48.08	53.69	70.24

Notes - Married white women, ages 25 - 55. Proportion working at least 20 weekly hours. In bold: women marrying down.

A.2 CPS Data

Data were taken from the Annual Demographic Survey (March CPS supplement) conducted by the Bureau of Labor Statistics and the Bureau of the Census. A detailed description of the survey can be found at www.bls.census.gov/cps/ads/adsmain.htm. Our data, for the years 1965−2011, were extracted using the Unicon CPS utilities.

The sample is restricted to civilian adults, ignoring the armed forces and children. We divided the sample into five education groups: high school dropouts (HSD), high school graduates (HSG), individuals with some college (SC), college graduates (CG), and post-college degree holders (PC). To construct the education variable, until 1991 we used the years of schooling completed and added 0.5 years if the individual did not complete the highest grade attended; from 1992 onward we simply used years of schooling completed.

Weekly wages are constructed by taking the previous year's wage and salary income and dividing it by the number of weeks worked in the previous year. Hourly wages are defined as the weekly wage divided by the number of hours worked in the previous week in all jobs, while annual (annualized) wages are defined as the weekly wage multiplied by 52. Wages are multiplied by 1.75 for top-coded observations until 1995. Nominal wages are deflated using the Personal Consumption Expenditure (PCE) index from National Income and Product Account (NIPA). Since wages refer to the previous year, we use the PCE for year $X - 1$ for observations in year X and, therefore, all wages are expressed in constant 2010 dollars.

Information on number of children under 6 for the period 1968 - 1975, which is missing from the survey data, is completed where possible using the distributions of this variable in 1967 and 1976 for each gender, marital status, and cohort separately. The completed

information can be used to construct an aggregate trend, but not to identify the number of children for a specific individual.

To construct a couple, we kept only heads of households and spouses (i.e., households with two families were dropped), and dropped households with more than one male or more than one female. We then merged women and men based on year and household identification, and dropped problematic couples such as those with two heads or two spouses, more than one family, or inconsistent marital status or number of children. We included in our sample married white females aged 25-55 to reflect schooling, marriage and employment patterns in each year. Individuals are considered employed if they reported working at least 20 hours weekly.

A.3 NLSY Data

Data for this section comes from the National Longitudinal Survey of Youth 1979 (NLSY79), a nationally representative sample of 12,686 men and women who were 14-22 years old at the time of the initial 1979 survey. We focus on white female members of the cross-sectional sample, a group of 2,477 young women chosen to be representative of the non-institutionalized civilian segment of the United States population in that age group. Members of this sample was re-interviewed annually from 1979-1994 and bi-annually since then, the most recent available wave being in 2008, when members of the sample were aged 43-52. In each wave, the NLSY contains information on marital status, schooling, labor force status (in past calendar year), income (in past calendar year) and other socioeconomic statuses, as well as the age, sex, education, labor force status, and income of each co-resident family member, including the spouse.

In our sample, 2,230 (90%) respondents are ever married and 247 have never married. For the purpose of the analysis, the data set was transformed into a panel data with multiple observations for each individual. A respondent is considered employed if she reported working at least 25 weeks and 20 hours per week in the past calendar year.

For the purpose of analysis, we only include couples that marry during the observation period so that we are able to follow a couple from the beginning of the marriage onwards until they get divorced or until observations are right-censored. Of the 2,230 who are married, 2,142 have entered into a first marriage during our study period. Of these, 864 ended their first marriage by divorce during 1979-2008. The duration of marriage in the sample ranges from 0 to 29 years.

We first identify women who entered into first marriages during 1979-2008. At the time of the woman's first marriage, we calculate the information on variables that will be fixed as long as we observe the respondent in that union (e.g. age, and education at first marriage, and husband's age, and education at the time of marriage). Respondents missing age and/or education information at the time of marriage for the wife or the husband were dropped (29 respondents). Then we create a series of observations, one for each completed interview, beginning with the first year of marriage. This series of observations ends either in the year of marital dissolution or in the 2008 interview for women who had not ended their first marriage during the panel. In addition to the fixed variables, each observation in the series contains information, measured in each interview year, on wife's and husband's employment status, and income. Our sample of 2,142 women, in their first marriage, contributes to a total of 23,622 observations in the panel. Divorce occurrence is defined as a dummy variable that takes the value of one if the respondent is observed divorced in

the next interview year.

Table A.3: Parameter Estimates

Utility Function		
Utility from leisure - female α_{1W}	301.544	(9.899)
Utility from children - single female α_{2W}	57.359	(0.848)
Utility from children - married female α_{3W}	17.366	(0.118)
Utility from children - married male α_{3H}	66.366	(1.752)
Intertemporal elasticity of substitution χ	0.941	(0.075)
Home Production		
Productivity shift from young children in housework $\gamma_{1,0-5}$	51.870	(0.208)
Productivity shift from older children in housework $\gamma_{1,6-18}$	38.389	(0.292)
Productivity shift from young children in market goods $\gamma_{2,0-5}$	7.260	(0.315)
Productivity shift from older children in market goods $\gamma_{2,6-18}$	7.327	(0.544)
Productivity of housework labor δ_W	850.549	(7.392)
Elasticity of substitution between housework labor and market goods ς	0.782	(0.037)
Fertility Process		
Being employed in previous period λ_1	-0.002	(0.000)
Being married λ_2	0.904	(0.028)
Age interacted with HSG attainment λ_3^{HSG}	-0.087	(0.004)
Age interacted with SC attainment λ_3^{SC}	-0.088	(0.028)

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Table A.3 – continued from previous page

Age interacted with CG attainment λ_3^{CG}	-0.088	(0.002)
Age interacted with PC attainment λ_3^{PC}	-0.059	(0.008)
Age squared interacted with HSG attainment λ_4^{HSG}	0.000	(0.000)
Age squared interacted with SC attainment λ_4^{SC}	0.001	(0.000)
Age squared interacted with CG attainment λ_4^{CG}	0.001	(0.000)
Age squared interacted with PC attainment λ_4^{PC}	0.000	(0.000)
Husband's education λ_5	0.116	(0.172)
Number of children in the household λ_6	-0.040	(0.002)
Wage Process, Female		
Returns to experience φ_{2W}	0.053	(0.021)
Returns to squared experience φ_{3W}	-0.001	(0.000)
HSG returns φ_{4W}^{HSG}	9.482	(0.224)
SC returns φ_{4W}^{SC}	9.636	(0.133)
CG returns φ_{4W}^{CG}	10.056	(0.205)
PC returns φ_{4W}^{PC}	10.446	(0.066)
Variance of wage shock $\sigma_{\epsilon_W}^2$	0.443	(0.014)
Wage Process, Male		
Returns to experience φ_{2H}	0.063	(0.002)
Returns to squared experience φ_{3H}	-0.001	(0.000)

Continued on next page

Table A.3 – continued from previous page

HSD returns φ_{4H}^{HSD}	9.455	(0.066)
HSG returns φ_{4H}^{HSG}	9.637	(0.130)
SC returns φ_{4H}^{SC}	9.805	(0.081)
CG returns φ_{4H}^{CG}	10.138	(0.407)
PC returns φ_{4H}^{PC}	10.394	(0.075)
Variance of wage shock $\sigma_{\epsilon_H}^2$	0.597	(0.024)
Job Offer, Female		
Working previous period ρ_{1W}	3.896	(0.088)
HSG ρ_{2W}^{HSG}	-0.805	(0.033)
SC ρ_{2W}^{SC}	-0.655	(0.015)
CG ρ_{2W}^{CG}	-0.448	(0.037)
PC ρ_{2W}^{PC}	-0.093	(0.002)
Accumulated experience ρ_{3W}	-0.028	(0.001)
Marriage Market and Match Quality		
Probability of meeting a partner p	0.319	(0.013)
Variance of starting bliss shock σ_Q^2	2.410	(0.155)
Compatibility benefit - HSG θ^{HSG}	612.250	(1.832)
Compatibility benefit - SC θ^{SC}	108.755	(0.267)
Compatibility benefit - CG θ^{CG}	791.364	(1.001)

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Table A.3 – continued from previous page

Compatibility benefit - PC θ^{PC}	783.260	(1.322)
Probability of a positive bliss shock P_Q^+	0.223	(0.016)
Probability of a negative bliss shock P_Q^-	0.245	(0.056)

Notes - Standard errors in parentheses. Men always work so some male parameters are not estimated.

A.4 Alternative Explanations

A.4.1 Schooling and Non-market Productivity

Pencavel (1998) suggests that in more educated couples, the women might choose to work less, in order to stay home with their children. He argues that schooling yields nonmarket as well as market benefits, or more specifically, greater schooling indicates greater nonmarket productivity. This higher nonmarket productivity is suggested by the advantages conferred on the children of better-educated parents. Pencavel (1998) estimates a model in which the dependent variables is work hours and not employment, and he is not analysing the effect of the female's relative position in education within the household but only adds the spouse's education level to the work hours regression of the individual. His estimation suggests that in a more educated couple, the husband will work more while the wife will work less, investing more of her leisure in the couple's (young) children. He also notes that the effect of the spouse's schooling on the individual labor supply is stronger for couples with young children. Given that, one should consider interactive effects between wife's relative education and presence of a young child, in addition to the main effects that are controlled for already, see Table 1.3). If relative wife's education is associated with her non-market productivity in the early child rearing years, interaction effects could explain the observed variation associated with wife's relative education and her labor supply behavior.

We estimate the basic model of female employment again, adding an interaction term between the two indicator dummies for the relative position in education and the presence of a young child.[39] Comparing column (1) with column (2) in Table A.4, we see that the

[39] Alternatively, we estimated the basic model separately for couple with and without children 0-6.

main effects for marrying down or up fell slightly but are still sizeable (marginal effects are of 3.2 and 1.5 percentage points, respectively). The effects are more pronounced for those with a young child, in particular for those where the female married up. The estimates for the interaction terms indicate that a married up woman might choose to work less in order to invest more time in her children, the marginal effects among the married up females are of 3 percentage points. Yet, the effect of young children is not substantial among married down women (marginal effects are of 1 percentage point). To conclude this section, we can argue that although children (particularly young ones) play a role in the employment decision of married down versus married up women, the non-market productivity hypothesis can't explain the differences in employment rates, suggesting there is room for other explanations.[40]

A.4.2 The Unemployment Risk Hypothesis

Another possible explanation derives from the correlation between the spouse's unemployment risk and his education level. We already know that women married to a less educated man will choose to work more regardless of his income. Yet, it might be the case that the women decide upon her employment according to the long term income of the husband and not according to his income in the previous period. In this case, if less education indicates higher instability in the labor market, a woman married to a less educated man might choose to work more as an insurance against the possibility her husband will lose his

Results were similar.

[40] Beck and González-Sancho (2009) find a positive impact of marital homogamy on child outcomes. Enhanced levels of parental agreement about the organization of family life and symmetry in the allocation of time to child care emerge as the intervening mechanisms behind this association. Yet, in our model's result the asymmetry between the behaviour of married up and married down women is very strong, the comparison between homogamous and heterogamous couples can't provide an explanation for the phenomenon.

job. This is known as "The Added Worker Effect (AWE)". So as to check this hypothesis, we created Unemployment Indexes that capture the probability of a specific individual to be unemployed in a specific year according to the individual's characteristics (occupation, education, age, industry)[41]. We tested the hypothesis using five different indexes for unemployment. The estimated marginal effects of our two main variables of interest when including each of these indexes as controls separately (Table A.5, columns (2) through (6)) do not differ significantly from the base model results (column (1)). The marginal effects of the unemployment indexes are trivial and insignificant. We conclude that the unemployment risk effect has no marked impact in the static framework. This is in line with results in the AWE literature. Empirical studies have generally been unable to uncover significant magnitude of AWE (Heckman and MaCurdy, 1980; Lundberg, 1985; Cullen and Gruber, 2000). Heckman and MaCurdy (1980) showed that in a life cycle context the AWE should be relatively small as wives of husbands facing greater risk of unemployment will usually work more hours, not necessarily at the point when husbands are unemployed. The later holds as long as the income loss from a short spell of unemployment is small relative to husband's lifetime earnings.

A.4.3 The Divorce Risk Hypothesis

Previous research has shown that couples are more likely to divorce when they do not share the same education background, particularly when it is the wife who has more education. These negative effects appear to have remained unchanged over time and, by some estimates, may have even increased (Heaton, 2002; Teachman, 2002). Given

[41] The unemployment index is the proportion of unemployed individuals in a specific group, e.g., the percentage of unemployed individuals in an occupation x in year y will be the probability to become unemployed to an individual with occupation x in year y.

the steady rise in the number of marriages in which wives have more education than their husbands (see 1·1), one would expect divorce rates to have increased as a result. Instead, after increasing through the late 1970s, they have gradually declined (Stevenson and Wolfers, 2007). Nevertheless, we want to examine whether the negative coefficient of the education gap actually captures a higher probability of divorce. In other words, we want to examine the "precautionary working" hypothesis. Namely, that married down women are working more in order to increase their experience and therefore their potential earning in a case of marriage dissolution (Becker et al., 1977).[42]

Data[43]

To test this hypothesis, we can't use the CPS since we can't detect the ex-spouse education, once the individual is divorced. In order to capture the pre-divorce characteristics of the couple we need a panel data set. Data for this section comes from the National Longitudinal Survey of Youth 1979 (NLSY79), a nationally representative sample of 12,686 men and women who were 14-22 years old at the time of the initial 1979 survey. We focus on white female members of the cross-sectional sample, a group of 2,477 young women chosen to be representative of the non-institutionalized civilian segment of the United States population in that age group. Members of this sample were reinterviewed annually from 1979-1994 and bi-annually since then, the most recent available wave being in 2008, when members of the sample were aged 43-52. In each wave, the NLSY contains information on marital status, schooling, labor force status (in past calendar year), income (in past calendar year) and other socioeconomic statuses, as well as the age, sex, education,

[42] Fernandez and Wong (2011) argue that the increase in the probability of divorce can explain a large proportion of the observed changes in female LFP from the 1935 to the 1955 cohort.

[43] **For more details about the data and variable coding, see A.3**

labor force status, and income of each co-resident family member, including the spouse. A respondent is considered employed if she reported working at least 25 weeks and 20 hours per week in the past calendar year. Of the 2,230 married women, 864 (39%) ended their first marriage by divorce during 1979-2008. The duration of marriage in the sample ranges from 0 to 29 years.

Educational Matching

Table A.7 illustrates the frequencies and percentages of the marriage matching distribution by educational attainment categories at the time of marriage. It can be seen that educational homogamy is most common - 49% (sum of diagonal). For about 25% of the couples we observe a higher educated wife. Spouses with strongly divergent education categories are uncommon: only 9 couples consist of a wife three education categories higher than her husband's - CG wife/ HSD husband, and PC wife/ HSD or HSG husband; 13 couples consist of a husband three education categories higher than his wife's - CG husband/ HSD wife, and PC husband/ HSG wife.

Wife's Employment and Educational Disparity Between the Spouses

We now wish to examine whether the employment phenomenon found in CPS hold for the NLSY. Similar to the CPS, we consider white married[44] women age 25-55. By age 25, 90% are no longer enrolled in any college/university. We estimate the preferred model specification in Table 1.3 using the NLSY sample. We regress wife's employment status on the two dummy variables for whether the female married down, married up, a set of control variables, and standard errors are clustered at the individual level. The results are shown

[44]We exclude 11 couples that marry before the first interview so we will have the education gap at the day of marriage.

in Table A.6, column (1) and our earlier results are re-established. Women that marry down have a higher probability of being employed, even after controlling for husband's income, and results are highly significant. The estimated logit coefficients indicate that marrying down vs marrying up has an average marginal effect of 6 percentage points.[45] The magnitude of the later implies an increase of about 10 percent in wives' employment rate[46]. The estimated coefficients of the other independent variables are properly signed and significant: probability of being employed increases with education, and age; the likelihood for employment is reduced with husband's annual earnings, the presence of young children, and number of children.

Wife's Relative Position in Education and Divorce Risk

In Table A.8, for each of the feasible marital match cells, the rate at which these first marriages dissolve during the study period is computed. Respondents with higher educational attainment tend to have more stable marriages. This is true for both husbands and wives, and stronger for couple where both members have relatively high education (notice the pattern along bold diagonal). However, the influence of the educational disparity is small if any. The divorce rate for couples where the wife is more educated than her husband is 38%, comparing to 39% for couple where the husband is more educated than the wife and 42% for homogamous couples.

For our analysis, we estimate the probability of divorce in period t given explanatory

[45] Applying the same sample restrictions, the logit model for married females' employment yielded a remarkably similar marginal effect for married down vs married up is roughly 7 percentage points for the CPS 1960-1965 birth cohorts data (these are the NLSY79 birth cohorts).

[46] A similarly specified regression for male respondents in the panel produces small, and statistically insignificant results for the effect of educational disparities between the spouses on the husband's employment status.

variables in $t-1$ using a complementary log-log (cloglog) regression model.[47] We assume a non-parametric baseline and create duration-specific dummy variables, one for each spell year at risk. The analysis focuses on the effects of wife's relative position in education on the risk of divorce. We define, similar to the above, two dummy variables that indicate whether the husband is more educated than the wife or vice versa (couples with same level of education are the control group). We further include a set of variables to control for various other factors that may influence the risk of divorce: indicators for wife's and husband's education; wife's age; both spouses' income decile indicators; age gap at marriage (husband's - wife's); the number of children and the presence of young children.

Table A.9 shows the results. The standard errors reported in the table allow for arbitrary correlation between the disturbance terms within a couple (cluster). Regarding the impact of educational disparities between the spouses on the risk of divorce we see that controlling for everything else it has a negligible and insignificant effect. The effects of the other controls are consistent with the literature identifying the possible causes for marital instability (Becker et al., 1977). Higher age at first marriage is stability enhancing (Rotz, 2011). Women who get married later tend to have spent more time searching for the best matches and/or have gathered more information about their future spouses. This group of women should experience less post-marriage shocks and therefore have lower chance of getting divorced. Age gap within the couple has a positive but insignificant effect. Presence of children reduces the probability of divorce since they indicate an increase in marital-specific capital and such capital would be worth less in any other marriage or when being divorced. As expected, own and spouse's education level has a negative effect

[47] Results do not differ qualitatively if we use a logit model.

on divorce risk. Higher education level is a predictor of the partner's high levels of market as well as non-market skills. Thus, higher-educated couples gain more from marriage compared to the lower-educated couples and their risk of divorce is lower.

Judging by the result from the NLSY, it seems that the wife's relative education carries no extra risk of divorce. Therefore, the divorce risk hypothesis does not hold up.

A.4.4 Selection

Let us now examine whether pre-marriage characteristics (ability, expectations or attitudes) of the couple can explain the different behaviour. The following section will try to address whether there is selection into marriage: assume two types of women, women with utility from consumption only and women with utility both from consumption and work.[48] Following this assumption, women with higher utility from work might choose to marry a less educated husband making her the main breadwinner at the household. On the other hand, we can assume two types of men in the population, one preferring to marry higher educated women and one preferring less educated women. It is impossible, of course, to check those assumptions directly since the type of the individual is unobserved, therefore we will use observed pre-marriage characteristics of the couple that might be correlated with the unobserved type of the individual. Comparing the characteristics of the married up women with those of the married down women will help us decide whether a selection into marriage exists. In this discussion, we will use both the CPS sample and the NLSY sample that were used in the previous chapters (and are described in detail in Appendix C).

[48] The difference between the two types can be in preferences toward work, children, leisure and so on.

Females' Pre-marriage Characteristics

In order to study female selection into marriage, we looked at pre-marriage variables that might be correlated with the unobserved work preferences of the women. We start with the age of marriage, assuming that a woman who married later, might have more experience and therefore higher wage and higher probability to be employed. Overall, although educated women married later, there was no significant difference in the married up to married down women age at marriage (see Table A.10). The average age of married for HS dropouts was below 20 compared to an average of above 31 for post-graduates, but at each education group, married down women married a year younger compared to married up women. In addition, we observe that women marrying down married younger husbands (a year and a half younger compared to the married up group).

We then check for whether the reason the married down women work more is because of their higher unobserved ability. We examine the average score on the AFQT, as a measure to the person's underlying ability. As shown in Table A.11, it turned out that the married down women have lower average scores than the married up women. In each education group, the women with higher scores married more educated husband compared to women with lower scores, this result is not surprising. Nevertheless, it fails to explain why those with the lower scores will choose higher employment rates.

Next, we examine whether there is a difference in the preference for children between the two "types" of women, namely, whether a woman who plans a big family, might choose a more educated husband who will enable her to work less. The NLSY79 survey contained in several rounds a direct fertility expectation question.[49] Respondents were asked about

[49]The survey question: "Altogether, how many (more) children do you expect to have?". For those

how many children they actually expected, which is considered a good predictor of future fertility outcomes. As shown in Table A.12, conditional on the female's education category there are no significant differences in mean expected number of children across the three match types (married up, equal, and down). These data are drawn from the survey year closest to the year the respondent was 21.[50] We follow by looking at differences in actual number of kids at the age of 40, Table A.13, when most women had completed their family planning. We couldn't find any significant variation in the average number of children in the household. We also implemented this analysis using the CPS sample, reaching the same conclusion.

One might be concerned that this is a classic case of selection on women's attitudes towards females' roles in the household. The NLSY elicits the individual's opinion towards a female's roles in home-making and in the labor market. In 1979, 1982, 1987 and 2004, respondents are asked whether they strongly disagree (1), disagree (2), agree (3) or strongly agree (4) with different statements. Among those, we believe that the most straightforward statement, defining a woman's role, is "A woman's place is in the home, not in the office or shop". Table A.14 displays the mean response by the female's relative position in education and education level, using responses from the survey year closest to the year the respondent was 21 (as above). The table reveals no substantial variation in opinion across females married up, equal or down, given their respective education level. The responses also reflect that lower education level is associated with "more traditional" views, i.e., women should specialise in home production and men in market production.[51]

women who already had children, the (total) expected number of children is given by expected number of children plus the number of children already born.

[50] The respondent may be as young as 19 or as old as 23 years of age.

[51] Responses to the other similar statements reveal the same patterns in attitudes.

Finally, a probit model (table A.15), for each female education group, is applied to an indicator for being married down to estimate the relevance of the various female attributes. In addition to AFQT, number of expected children, attitude towards female's roles, we added a measure of physical attractiveness (proxied by BMI[52]). The results are consistent with the above statistics: AFQT is negatively and significantly correlated with marrying down; attitudes and expectations on the number of children are not relevant. Some evidence is found among some college and college graduate females that married down females are more likely to be overweight or obese. However, introducing BMI to the employment equation indicates no significant correlation between the two measures.

Males' Pre-marriage Characteristics

We question whether the more educated husbands have different characteristics, allowing their wives to work less. We are interested in whether the male marriage premium differs for those that marry up, i.e., a more educated female, compared to those that marry equally or down. Although we already ruled out the husband's income playing a large role, if any, in the wife's employment decision, we estimate a log wage regression for the husband controlling for the type of women he married. Virtually all studies find that married men tend to earn significantly more than single men, with estimates of the marriage premium usually exceeding 10 percent, depending on the time period, sample examined, and model specification (Goldin, 1990; Gray, 1997). Using CPS, in our specification, we consider only married males and the parameter estimate of interest is for a dummy variable indicating "married up". Marriage is coded into three separate categories (married up, down and

[52]Height and weight measures were used to calculate body mass index (BMI), which was then categorized as underweight (< 18.5), normal weight ($>= 18.5$ and < 25), overweight ($>= 25$ and < 30), and obese ($>= 30$). These data are drawn from the survey year closest to the year the respondent was 21.

equal) and the comparison is between those married equal and married down.[53] As shown in Table A.17, the result indicates that husbands married to a more educated female earn 5% more per hour, the reference group being the homogamous marriages. This is consistent with mean AFQT scores, displayed in Table A.16, for male respondents in the NLSY sample. Notice the higher mean score among men marrying up (females marrying down) conditional on educational attainment, while the average score increases monotonically with education level. This suggests that the male marriage premium mirrors the marriage selection pattern. An educated woman might choose to marry a less educated husband if his ability is higher with respect to his counterparts in the same education group. While this finding can help us rationalize the match between the couple, it can't explain why those women are working more.

[53]Control variables include education, full time full year indicator, and potential experience (age-education-6) quartic. The presence of children is controlled with two dummy variables: a child younger than 6 in the family and the number of children in the family. Other controls include dummy variables for survey year and MSA fixed effects.

Table A.4: Estimated Effects Including Interactions

VARIABLES	(1)	(2)
Female married down (d)	**0.037*** **	**0.032*** **
	(0.003)	**(0.003)**
Female married up (d)	**-0.023*** **	**-0.015*** **
	(0.003)	**(0.003)**
F married down X presence of child 0-6		**0.012*** **
		(0.004)
F marriedup X presence of child 0-6		**-0.032*** **
		(0.004)
Female post graduate (d)	0.293***	0.297***
	(0.006)	(0.006)
Female college graduate (d)	0.204***	0.209***
	(0.006)	(0.006)
Female some college (d)	0.162***	0.167***
	(0.005)	(0.005)
Female high school graduate (d)	0.111***	0.114***
	(0.004)	(0.004)
Age	-0.003*	-0.003*
	(0.002)	(0.002)
Age gap	-0.001	-0.001*
	(0.000)	(0.000)
Number of children in the HH	-0.043*	-0.043*
	(0.025)	(0.025)
Presence of a child 0-6	-0.233***	-0.228***
	(0.002)	(0.002)
Male post graduate (d)	0.029***	0.023***
	(0.008)	(0.008)
Male college graduate (d)	0.059***	0.053***
	(0.006)	(0.007)
Male some college (d)	0.096***	0.090***
	(0.005)	(0.005)
Male high school graduate (d)	0.059***	0.055***
	(0.004)	(0.004)
Dummies for the deciles of Husband's annual income	YES	YES
Time dummies	YES	YES
MSA fixed effects	YES	YES
Observations	681,503	681,503

Notes - Married white women, ages 25 - 55. Employment indicator is one when working at least 20 weekly hours. Marginal effects (instead of logit coefficients) are reported. *** p<0.01, ** p<0.05, * p<0.1. (d) for dummy variable. Reference education group: HSD. Column (1) is identical to column (6) in table 1.3 (the preferred specification) and is reproduced here to facilitate comparison.

Table A.5: Estimated Effects Including Unemployment Indexes

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Female married down (d)	**0.037*** (0.003)**	**0.040*** (0.003)**	**0.040*** (0.003)**	**0.041*** (0.003)**	**0.040*** (0.003)**	**0.040*** (0.003)**
Female married up (d)	**-0.023*** (0.003)**	**-0.025*** (0.003)**	**-0.024*** (0.003)**	**-0.024*** (0.003)**	**-0.024*** (0.003)**	**-0.024*** (0.003)**
Occupation unempl index		-0.003 (0.002)				
Industry-Occupation unempl index			-0.001 (0.000)			
Industry unempl index				-0.003 (0.002)		
Occupation-Age-Education unempl index					-0.000 (0.000)	
Age-Education unempl index						-0.001 (0.001)
Dummies for the deciles of Husband's annual income	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
MSA fixed effects	YES	YES	YES	YES	YES	YES
Observations	681,503	681,503	681,503	681,503	681,503	681,503

Notes - Married white women, ages 25 - 55. Employment indicator is one when working at least 20 weekly hours. Marginal effects (instead of logit coefficients) are reported. All models include indicators for own and spouse education, own age, age gap, number of children in the HH and an indicator for the presence of a child 0-6. *** p<0.01, ** p<0.05, * p<0.1. (d) for dummy variable. Reference education group: HSD. Column (1) is identical to column (6) in table 1.3 (the preferred specification) and is reproduced here to facilitate comparison.

Table A.6: NLSY - Logit Regression on Employment for Married Age 25-55

VARIABLES	(1) Married Females
Female married down (d)	**0.357**** **(0.180)**
Female married up (d)	**-0.081** **(0.175)**
Female post graduate (d)	1.010* (0.528)
Female college graduate (d)	1.084*** (0.382)
Female some college (d)	0.860*** (0.298)
Female high school graduate (d)	0.707*** (0.192)
Age	-0.011 (0.018)
Age gap	-0.006 (0.010)
Number of children in the HH	-0.400*** (0.035)
Presence of a child 0-6	-0.874*** (0.062)
Male post graduate (d)	0.043 (0.499)
Male college graduate (d)	0.079 (0.391)
Male some college (d)	-0.004 (0.304)
Male high school graduate (d)	0.004 (0.194)
Dummies for the deciles of spouse's annual income	YES
Time dummies	YES
Observations	18,460

Notes - Standard errors are corrected for clustering within individual - 1,823. *** p<0.01, ** p<0.05, * p<0.1. (d) for dummy variable. Reference groups: High school dropouts; Females married homogamously.

Table A.7: NLSY - Distribution of Marital Matching by Education

Wife's	Husband's Education					
Education	HSD	HSG	SC	CG	PC	Total
High School Dropout (HSD)	130	131	20	4	0	285
	6.07	6.12	0.93	0.19	0.00	13.31
High School Graduate (HS)	150	571	160	53	9	943
	7.00	26.66	7.47	2.47	0.42	44.02
Some College (SC)	25	173	135	97	24	454
	1.17	8.08	6.30	4.53	1.12	21.20
College Graduate (CG)	4	63	72	178	62	379
	0.19	2.94	3.36	8.31	2.89	17.69
Post College Degree (PC)	1	5	15	27	33	81
	0.05	0.23	0.70	1.26	1.54	3.78
Total	310	943	402	359	128	2142
	14.47	44.02	18.77	16.76	5.98	100.00

Notes - First row reports the number of observations. Second row shows the cell percentage

Table A.8: NLSY - Proportion of Marriages that Dissolve by Educational Matching

Wife's	Husband's Education					
Education	HSD	HSG	SC	CG	PC	Total
High School Dropout (HSD)	**0.68**	0.54	0.65	0.75	.	0.61
	130	131	20	4	0	285
High School Graduate (HS)	0.57	**0.44**	0.43	0.30	0.22	0.45
	150	571	160	53	9	943
Some College (SC)	0.40	0.38	**0.43**	0.30	0.17	0.37
	25	173	135	97	24	454
College Graduate (CG)	0.25	0.25	0.22	**0.22**	0.16	0.22
	4	63	72	178	62	379
College Graduate (CG)	1.00	0.00	0.40	0.15	**0.09**	0.17
	1	5	15	27	33	81
Total	0.60	0.43	0.40	0.26	0.15	0.40
	310	943	402	359	128	2142

Notes - In each cell, first row shows the probability of marriage termination for first marriages. Second row reports the number of observations.

Table A.9: NLSY - Cloglog Estimates on Probability of Divorce, First Marriages Only

VARIABLES	(1)	(2)	(3)
Female married down (d)	**0.183***	**-0.056**	
	(0.093)	**(0.179)**	
Female married up (d)	**-0.158***	**0.004**	
	(0.091)	**(0.180)**	
Female post graduate (d)	-0.937***	-0.321	-0.408
	(0.309)	(0.589)	(0.325)
Female college graduate (d)	-1.086***	-0.637	-0.702***
	(0.160)	(0.411)	(0.168)
Female some college (d)	-0.598***	-0.269	-0.321**
	(0.134)	(0.303)	(0.133)
Female high school graduate (d)	-0.368***	-0.160	-0.184*
	(0.104)	(0.180)	(0.103)
Age at marriage	-0.037***	-0.040***	-0.040***
	(0.011)	(0.011)	(0.011)
Age gap	0.010	0.009	0.009
	(0.008)	(0.008)	(0.008)
Number of children in the HH	-0.153***	-0.133***	-0.133***
	(0.049)	(0.049)	(0.049)
Presence of a child 0-6	-0.063	-0.009	-0.010
	(0.093)	(0.093)	(0.093)
Male PC (d)		-0.840	-0.759***
		(0.544)	(0.271)
Male CG (d)		-0.510	-0.443***
		(0.406)	(0.157)
Male SC (d)		-0.190	-0.142
		(0.299)	(0.124)
Male HSG (d)		-0.326*	-0.296***
		(0.176)	(0.098)
Dummies for the deciles of spouse's annual income	NO	YES	YES
Dummies for the deciles of wife's annual income	NO	YES	YES
Marriage duration dummies	YES	YES	YES
Observations	23,622	23,622	23,622
Clusters	2,142	2,142	2,142

Notes - Standard errors are corrected for clustering within couples; *** p<0.01, ** p<0.05, * p<0.1. (d) for dummy variable. Reference groups: High school dropouts; Females married homogamously.

Table A.10: NLSY - Mean Age at Marriage

Wife's Education	Relative Position in Education			
	Married down	Married equal	Married up	Total
HS dropout	NA	19.13	20.18	19.70
HS graduate	22.19	22.41	23.80	22.70
Some college	24.20	23.87	26.07	24.60
College graduate	26.76	26.10	28.23	26.69
Post-graduate	31.04	31.85	NA	31.37
Total	24.92	23.12	23.78	23.74

Notes -

Table A.11: NLSY - Mean Wives' AFQT Score

Wife's Education	Relative Position in Education			
	Married down	Married equal	Married up	Total
HS dropout	NA	28,487	30,396	29,517
HS graduate	40,505	46,850	49,642	46,514
Some college	61,935	64,233	67,135	63,986
College graduate	76,438	78,569	82,348	78,408
Post-graduate	82,022	82,863	NA	82,369

Notes -

Table A.12: NLSY - Mean Expected Number of Children

Wife's Education	Relative Position in Education: Married down	Married equal	Married up	Total
HS dropout	NA	1.20	1.27	1.24
HS graduate	1.95	2.02	2.11	2.03
Some college	2.04	2.27	2.49	2.23
College graduate	2.34	2.65	2.50	2.51
Post-graduate	2.27	2.24	NA	2.26
Total	2.12	2.07	2.00	2.06

Notes -

Table A.13: NLSY - Mean Actual Number of Children

Wife's Education	Relative Position in Education: Married down	Married equal	Married up	Total
HS dropout	NA	1.04	1.20	1.14
HS graduate	1.47	1.65	1.86	1.68
Some college	1.74	2.00	1.92	1.86
College graduate	1.94	2.13	2.05	2.05
Post-graduate	1.33	1.61	NA	1.45
Total	1.71	1.79	1.76	1.76

Notes - In 2004, when the youngest women in the sample completed their 40th birthday, most women were with completed fertility. The oldest female in that survey year was 47 years of age.

Table A.14: NLSY - Gender Role Attitudes Mean Score at Age 21

Wife's Education	Relative Position in Education: Married down	Married equal	Married up	Total
HS dropout	NA	1.86	1.85	1.85
HS graduate	1.84	1.79	1.66	1.77
Some college	1.59	1.77	1.53	1.62
College graduate	1.45	1.46	1.44	1.45
Post-graduate	1.29	1.28	NA	1.29

Notes -

Table A.15: Probit Estimates by Education Group (Dependent Variable: Marrying Down)

VARIABLES	(1) High School Graduate	(2) Some College	(3) College Graduate	(4) Post-Graduate
AFQT (in thousands)	-0.006**	-0.006**	-0.007*	0.005
	(0.002)	(0.003)	(0.004)	(0.010)
Gender role Attitudes	0.094	-0.109	-0.007	0.175
	(0.070)	(0.086)	(0.117)	(0.314)
Children expectations	-0.012	-0.099**	-0.078	0.004
	(0.042)	(0.049)	(0.051)	(0.117)
Underweight	-0.028	-0.187	-0.498*	0.438
	(0.180)	(0.197)	(0.276)	(0.452)
Overweight	0.197	0.416**	0.725**	
	(0.151)	(0.204)	(0.290)	
Obese	0.364	0.507	1.021**	
	(0.230)	(0.495)	(0.511)	
Observations	873	423	354	72

Notes - Married white women, first marriages. *** p<0.01, ** p<0.05, * p<0.1.

Table A.16: NLSY - Mean Husbands' AFQT Score

Husband's Education	Relative Position in Education			
	Married down	Married equal	Married up	Total
HS dropout	NA	17,988	23,782	21,286
HS graduate	40,184	43,915	49,500	44,740
Some college	60,114	63,532	66,001	62,552
College graduate	74,462	79,375	85,830	77,874
Post-graduate	82,604	92,123	NA	85,079

Notes - Married respondents men in the sample. Men who marry down (up) are men that marry women of lower (higher) education level than themselves. A male marrying down means that the female marry up, and vice versa.

Table A.17: CPS - Log Hourly Wage for Married Men

VARIABLES	(1)
Male married up (d)	**0.047*** **
	(0.002)
Male married down (d)	**-0.057*** **
	(0.002)
Male post graduate (d)	0.896***
	(0.005)
Male college graduate (d)	0.772***
	(0.004)
Male some college (d)	0.509***
	(0.004)
Male high school graduate (d)	0.303***
	(0.004)
Time dummies	YES
MSA fixed effects	YES
Observations	551,505

Notes - *** p<0.01, ** p<0.05, * p<0.1. (d) for dummy variable. Sample consists of husbands married to white females aged 25-55. Reference groups: High school dropouts; Males married homogamously. Model includes: education category indicators, full time full year indicator, and potential experience (age-education-6) quartic. The presence of children is controlled with two dummy variables: a child younger than 6 in the family and the number of children in the family.

Chapter 2

Educational Assortative Mating for Blacks and Whites since the 1960s

2.1 Introduction

Who an individual marries and why are questions that have gained interest over the years since the earlier works of (Becker, 1974b, 1981). The tendency toward homogamous mating has been demonstrated along a number of different dimensions. Educational assortative mating has received notable attention because marriage patterns have implications for social mobility and income inequality. In this study I analyse how educational assortative mating evolved in the last five decades and show that different measures lead to different conclusions.

Earnings differentials by education have increased over the last half of the 20th century, especially since the late 1970s (Goldin and Katz, 2000; Katz and Autor, 1999; Gottschalk, 1997; Katz and Murphy, 1992). As in the case of individual wages and earnings, the family income disparity in the U.S. has sharply widened over the last several decades

(Levy, 1998). Between 1980-2009, the share of aggregate income received by the lowest fifth families fell from 4.4 percent to 3.7 percent, whereas, for the top five percent families it increased from 16.2 to 21.3 percent (U.S. Census Bureau).

On the other hand, starting with the 1970 birth cohort, women have attained higher college graduation rates than men (Goldin et al., 2006). The "gender revolution" (Goldin, 2006) and the rise in returns to education increased the incentives of highly educated men to seek out highly educated women. In light of all these facts, one would expect positive assortative mating to increase. Indeed, a great deal of studies have argued for an increase in educational assortative matching in the last five decades in the US (Fernandez et al., 2005; Schwartz and Mare, 2005; Mare, 2008).

In this context, there is a growing concern as to the contribution of assortative matching to inequality and its intergenerational reproduction. Rising rates of marital homogamy are one of the leading explanations for the rise in income inequality across households (Esping-Andersen, 2007; Kenworthy, 2004) and for the degree of intergenerational economic persistence (Chadwick and Solon, 2002). Fernandez et al. (2005), using an OLG model, 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", that is, increase in inequality increases the odds for homogamy. This in turn further increases inequality in the next generation to the extent that children inherit the educational characteristics of their parents.

The past several decades have also witnessed a decline in marriage rates that differ by education and race. However, while there is a voluminous literature analysing the

evolution of assortative mating in US, less attention has been given to analyse trends in assortative mating for blacks across cohorts (Stevenson and Wolfers, 2007).

Despite the dramatic changes in the second half of the twentieth century in the marginal distribution of education for both men and women, that differed by race, I find no substantial general trend of increased sorting neither for blacks nor for whites. However, there are increases in some of the local log odds over the period considered. These results are in line with the findings, for white couples, presented by Siow (2009). However, I provide a more comprehensive empirical analysis and explore differences in assortative mating across race. These findings are particularly interesting in the light of previous literature that was finding an increase in assortative mating over time, and, in turn, consequential effect on inequality. Most sociological studies, using log linear models, suggest that preference for homogamy have changed across cohorts in the US to produce an increase in homogamy, even after accounting for the changes in the marginal distribution of males and females in each group. Yet, as it will be shown in this paper, conclusion drawn about trends of homogamy depend on the educational grouping scheme. Following the classification commonly used in the wage structure literature (Acemoglu and Autor, 2010) I find large racial differences in these trends: homogamy rate for whites over the last four decades remained relatively unchanged, and if anything hints at a direction of slight decline, while for blacks homogamy rates declined sharply.

The structure of the paper is as follows. In Section II, I describe the data, and analyse the trends in assortative mating for the last five decades. For the later task, I make use of two measures of marital sorting: correlation coefficients, and local log odds ratio. In Section III, I give a detailed description of changes in the overall rate of marital homogamy.

Finally, section IV concludes.

2.2 Assortative Mating

2.2.1 Data

The data are from the 1960, 1970, 1980, 1990, and 2000 U.S. Census microdata, and from the 2010 American Community Survey (ACS) from IPUMS. To avoid the usual concerns of cohort overlap and age effects, I examine different female birth cohorts at a certain age. To examine assortative mating patterns over the life cycle, each cohort is then followed in two subsequent censuses. For example: the cohort of women born between 1926 and 1930 observed in the 1960 Census, at the age of 30-34, is observed ten and twenty years later in the 1970, and 1980 Census respectively. I keep only married couples and exclude multiracial marriages to avoid race effects. Excluding the racially mixed marriages has no significant effect on the results. Educational attainment is divided into five categories: $HS\,dropout$ (HSD), HS, $Some\,College$ (SC),$Bachelor$ (BA) and $Post\text{-}graduate$ (PC).

2.2.2 Correlation between Wife's and Husband's Education over the Life Cycle and across Cohorts

Table 2.1 shows single statistic measures of the correlation between wives' and husbands' educations[1] (gamma, tau-b, and Pearson's rho) for multiple cohorts, and at different stages of life for each. For white females (upper panel), 30-34 years of age , all three measures of correlation report consistent trends. Positive assortative mating across cohorts remained pretty stable. The changes from one cohort to the other, ranging form 0.01 to 0.03, are statistically significant, and robust to Bonferroni's correction. However, it is worth

[1]Husband-wife correlations by school years were computed and results were significantly similar.

noting that these are not substantial changes. Comparing the oldest cohort (1926-1930) to the youngest cohort (1966-1970), tau-b and rho correlation increased by 0.02, and 0.01 respectively. One sees what might look as a beginning of a decreasing trend in assortative mating when the oldest cohort, and the 1956-1960 cohort are compared at age 50-54. Tau-b and rho correlation declined by 0.04, and 0.05 respectively.

For the 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, examining life cycle patterns by cohorts reveals the same stable patterns and non-subtle changes. Table 2.1 reports the evolution of the association over the life cycle. For the youngest cohort, tau-b correlation at the age of 30-34 was 0.49, this compares with 0.51 at the age of 50-54 - this increase is in line with improved matches due to the longer wait and remarriage. In contrast, tau-b correlation was 0.50, and 0.47 at the age of 30-34, and 50-54 respectively.

Turning to blacks (lower panel), the same picture emerges - there was no change in the association between wife's and husband's education. It is striking that despite the well known differences in educational backgrounds, among other things, the levels of correlation are similar but somewhat lower than among whites throughout. Yet, it is important to note that, due to the small sample sizes, neither the differences by cohorts nor by age passed the significance tests.

2.2.3 Changes in Log Odds Ratios across Cohorts

Another very informative measure that describes the strength of association between two binary variables is the log odds ratio. The odds ratio is the ratio of the odds of an event occurring in one group to the odds of it occurring in another group. The larger the odds ratio, the greater the likelihood is of marrying someone from one particular group compared to marrying someone from the other group in question. For example, 1926-30 cohort's odds ratio for whites, among HS, SC females, and HSD, HS males is derived from the following contingency table which includes the number of observed couples in each cell:

Husband's Education	Wife's Education	
	HS	SC
HSD	12,232	6,783
HSD	3,756	8,082

In this example the log odds ratio would be $log[(12,232{*}8,082)/(3,756{*}6,783)] = 0.59$, which is the value reported in Table 2.2, first row, and second column. This means that the likelihood of being married to a white HS female vs. a SC female are higher for the HSD male than for the HS male. When the log odds is equal to one, this would mean that the odds are zero for the marriage to happen in any of the two groups in question.

Table 2.2, and table 2.3 present the log odds across cohorts, for whites, blacks respectively. For whites, for the most part, the log odds are positive, and significant except in some cases where for a potential marital match the marriage counts were trivial. For example, in the 1926-1930 cohort, the negative odds are for the CG, PC females. This means that HSD, HS, and SC males were less likely to marry the CG female than the PC

one.

Several facts should be highlighted by Table 2.2. The odds along the diagonals are clearly the highest. These also decrease as one shifts away from her own educational class. Comparing the odds for the oldest cohort with the those for the youngest cohort (panel in bold), I notice the transformation over time. Along the diagonals the differences are significantly positive for the HSD, and the SC groups, i.e., the strength of the association in these two groups has grown, more so for the HSD. This group might have become more isolated over time. However, for the HS, and CG groups the dependence seems to have slightly decreased (0.058, and 0.037 log points respectively). For the off diagonal elements the picture is clear: on the upper right the changes are mainly positive, whereas on the bottom left the changes are mainly negative. This indicates that over time, the odds for women to marry down have significantly increased while its clearly the opposite for males. This is not surprising given that women were becoming on average more educated than there male counterparts. These findings help in understanding the results presented in the previous section. It appears very likely that these non-monotone changes have cancelled each other such that no change in the strength of husband-wife relationship occurred over time. The roles are reversed in the sense that for the 1926-30 cohort men had higher educational attainment than women, making highly educated females scarce so that men had to marry down, whereas for the more recent cohort, 1966-70, its the mirror picture.

Turning to blacks (table 2.3), the log odds for homogamy (diagonal) are higher than those among whites for the oldest cohort, 1926-30. Yet, lower than those prevailing among whites for the 1966-70 one. The changes along the diagonal between the later two cohorts are not significantly different. On the top right, some changes are positive, and some are

negative, with one negative being highly insignificant. The positive changes are however more pronounced than those seen for the whites, and highly significant. There was a 0.3 log points increase in the odds of a SC black female to marry a HS vs. a SC black male; this compares to a 0.06 log points increase for the same group among whites. In addition to the educational expansion among blacks, just like among whites, this is explained by the changing marriage patterns among black women. Contrary to the historical pattern, for the more recent cohorts, black women with SC or higher are more likely to marry than black women with less education. The bottom left entries show the clear effects of these facts on males: males are less likely to marry down. Just like for whites, these non-monotone changes have cancelled each other such that no change in the husband-wife correlations of schooling came about over time.

2.3 Educational Homogamy

Table 2.4 shows the percentage distribution of wives and husbands level of educational attainment and changes in absolute rates of homogamy and intermarriage among prevailing marriages for young adults aged 30-34 for blacks and whites starting from the 1926-30 cohort, and ending with the 1966-70 cohort. Average educational attainment rose for both sexes over the five decades, particularly for women (the row totals). By 2000, wives had higher average educational levels than their husbands for both races. Starting from a lower base, the gains were larger among blacks and particularly among black wives. By 2000, the gender gap in the share of husbands and wives with at least bachelor degree was 3 percentage points among black couples (20.9 % for women and 17.7% for men) compared to a 1.7 percentage points gap among whites (31.9 % for women and 30.2% for men).

The proportions for educational attainment for husband and wives along racial lines are in line but slightly different compared to the educational expansion in the whole population, without the distinction of marital status. The distribution of educational attainment computed based on the married population reflects the marriage patterns that differ by race, and education for women and for men. For both Blacks and whites, marriage rates have declined since the 1980s among people of all educational backgrounds. However, while college-educated women used to be the least likely to marry, today they are about as likely as those without a college degree to marry. There are large racial differences in this trend: college-educated white women remain less likely to marry than those with less education, while college-educated black women are the most likely to marry among blacks. This difference is due to the larger shift away from marriage among blacks, particularly among those with less education (Goldin, 2004; Isen and Stevenson, 2010).

Among the married whites, the percentage of educationally homogamous couples (the sum of diagonal cells in Table 2.4) remained relatively stable throughout the period.

There is a consensus in the literature that educational homogamy during recent decades has been rising (Schwartz and Mare, 2005). The classification used in most studies is the grouping scheme defined as follows: $\prec$ 10, 10-11, 12 : HS, 13-15: $Some\,College$, 16+: $College\,graduate$. Using 1970-2010 March CPS data, and following the same sample restrictions as in Schwartz and Mare (2005), I first reproduce their results (see Figure 2.1) which show that between 1970 and 2010, the percentage of husbands and wives holding the same education category increased steadily, from 50 to 57 percent (15 percent increase). I then disaggregate these five educational categories differently, i.e., less and more detailed classification. First, I start with aggregation at the lower end ($\prec$ 10 +

$10 - 11 \equiv HS\,dropout$), the series referred to as Schwartz & Mare grouping dropout. Homogamy rates rise throughout, however, the upward shift is minimal later in the period, resulting in a moderate increasing trend. For the period under study, grouping those with elementary schooling and some high school is not concealing diversity as these were minorities (both categories diminishing over time) and the distinction was roughly between those that graduated high school and those that did not. Secondly, I will demonstrate that grouping according to the classification commonly used in the wage structure literature (Acemoglu and Autor, 2010) results in a stable homogamy rate over the last four decades and even hints at a direction of slight decline. The employed five level classification, which is also being used in this study, aggregates at the lower end and uses a more detailed classification at the top: $HS\,dropout$, HS, $Some\,College$, $Bachelor$ and $Post-graduate$. This is the most appropriate grouping reflecting the educational heterogeneity and the well-chosen attainment levels with a socio-economic significance when the fraction of college graduates holding a postgraduate degree has dramatically increased over time (Card and Lemieux, 1999), while $\prec 10$ category is shrinking among HS dropouts. Thus, by grouping all those with at least a college degree, studies overlook a significant source of educational diversity which exaggerates the rate of homogamy across time. These findings are critical as economics and macro literature on marriage rely on the work mentioned above to argue for increased assortative matching. For completeness, the series with 6 educational categories is displayed. The difference between this grouping and the previous one reflect the effects of merging those with less than ten years of schooling and those with some HS. Using this finer distinction produces a very similar trend. Adopting it might just distort the changes over time and create trivial frequencies in the cross tabulations of

spouses' education.

A different picture emerges when I examine homogamy trends among blacks. Educational homogamy has been sharply decreasing for black couples. The very high homogamy rate prevailing in 1960 (68%) is not surprising given the skewed educational attainment distribution (75% of men and 66% of women were HSD). By 2000, young couples, whites and blacks, had a similar level of educational homogamy. Among whites, some 48% of marriages consisted of couples with the same level of education in 2000, down from 50% in 1960. Among blacks, 49% of couples had the same level of education in 2000, down from 68% in 1960. For black couples, the rate decreased by 11 percentage points in the 1960s and then slowed down to 9 percentage points in the 1970s and then stabilized.

Table 2.5 shows the detailed trends in homogamy and intermarriage for women separately by education level for whites blacks respectively. The total homogamy rate among whites remained stable. There is an increase among women with HS, SC, and CG education. The average trend, however, was offset by a decline in homogamous marriages among PC educated women (a group expanding over time), and HSD (a group shrinking over time) a decline of 17, and 20 percentage points respectively. As mentioned earlier, women's educational attainment became highly skewed towards the upper part of the distribution. Their college and graduate school attendance sharply increased across the four cohorts. The more educated women are more likely to marry down in 2000 than in 1970. Thus, if one partner in a marriage has more education than the other, it is likely to be the wife in the later cohort. Among whites, 28% of marriages the wife is more educated than her husband in 2000, up from 22% in 1960 (30% rise).

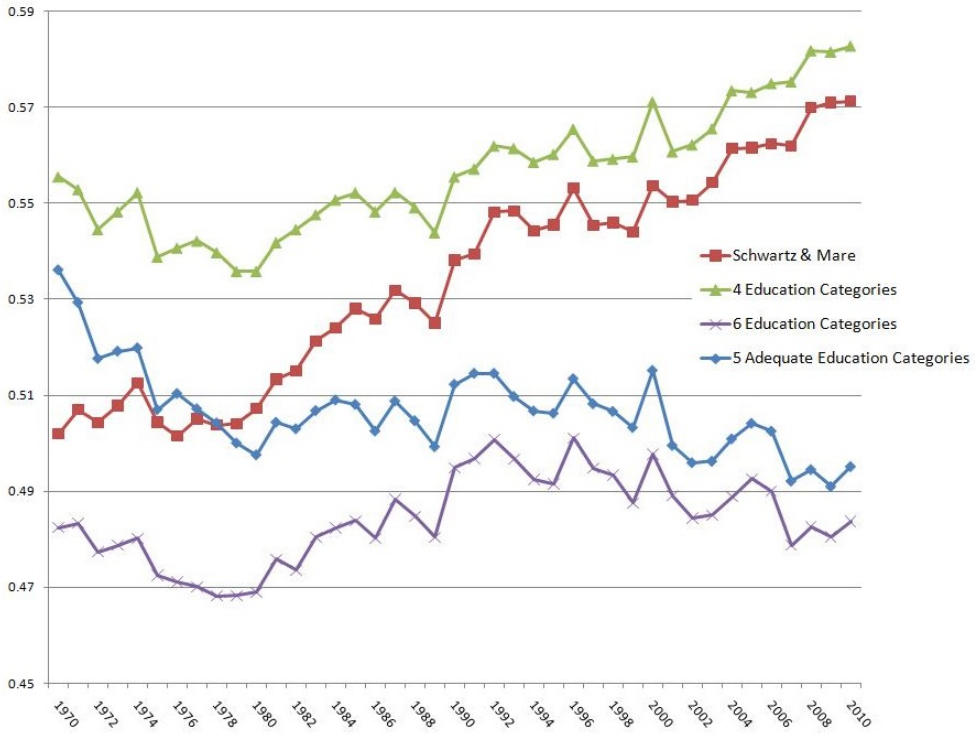
The experience for black women is different. Average homogamy rates declined among

black women. Similar to whites, there is an increase among women with HS, SC, and CG education, and a decline among HSD, and PC. However, despite the rise, these homogamy rates remained much lower than the one prevailing among the HSD. The high homogamy rates for the oldest cohort should not be surprising as the HSD group, which was driving the homogamy rate, comprised 66% of the black married female population in 1960, down to only 6.5%. The PC educated black women are more likely to marry down in 2000 than in 1970. On average, black females are more likely to marry down, and up, 100%, and a 50% increase respectively. Yet, it is important to note that the much smaller sample sizes might yield imprecise frequencies.

2.4 Conclusion

This article focuses of analysing assortative mating patterns among white, and black married young couples from the US 1960, 1970, 1980, 1990, and 2000 census, and the 2010 ACS. Comparing cohorts, results reveal several clear trends. First, there is no clear increase in overall assortative mating over time. Rather, correlations indicate stability over time, life cycle and across races. Second, there are local changes in log odds indicating a higher tendency to match with one's own education level for HS, and SC whites. For whites, as well as for blacks, the matching patterns observed are driven by women surpassing men's educational attainment in the younger cohorts. The log odds reveal that women born in 1966-70 are more likely to marry down than those born on 1926-30. This changing pattern was more pronounced among the more educated black women, the reason being the changing marriage patterns for the different racial and education groups. Over time, women of all education groups, in both races, shifted away from marriage but at a different

Figure 2.1: Odds of Homogamy, Wives aged 18-40: 1970-2010



Notes - Data are derived from 1970-2010 March CPS. (1) - Schwartz & Mare: $\prec$ 10, 10-11, 12, Some College, College; (2) - Schwartz & Mare but group the dropouts: dropouts, 12, Some College, College; (3) - 6 Education Categories (disaggregated Dropouts and College): <10, 10-11, 12, Some College, College, Post-College (Masters, PhD,..); (4) - 5 Adequate education categories (disaggregated College): dropouts, 12, Some College, College, Post-College (Masters, PhD,..)

pace. For the youngest cohort, the marriage pattern is reversed, and the more educated black women have higher rates of marriage compares with the less educated. Finally, the overall absolute rates of homogamy have unambiguously decreased for blacks over the five decades, yet, remained unchanged for whites.

Findings regarding assortative mating are highly sensitive to modelling choices, educational grouping scheme, and measures. The results presented in this paper cast doubt on the validity of the claim that assortative mating have increased over time, and in turn, contributed to the rising household income inequality.

Table 2.1: Educational Assortative Mating across Cohorts and over the Lifecycle

White Females						
Cohort		1926-1930	1936-1940	1946-1950	1956-1960	1966-1970
Age 30 - 34	Gamma	0.6776	0.6869	0.6946	0.6479	0.6563
	Tau_b	0.49	0.5114	0.5434	0.4962	0.509
	Rho	0.583	0.6027	0.6239	0.5708	0.5872
Age 40 - 44	Gamma	0.6667	0.6838	0.6498	0.6199	0.6228
	Tau_b	0.4849	0.5192	0.5087	0.4748	0.4902
	Rho	0.5697	0.6022	0.586	0.552	0.5719
Age 50 - 54	Gamma	0.6746	0.6435	0.6344	0.6076	
	Tau_b	0.5095	0.4952	0.4939	0.4697	
	Rho	0.598	0.5751	0.5717	0.549	
Black Females						
Cohort		1926-1930	1936-1940	1946-1950	1956-1960	1966-1970
Age 30 - 34	Gamma	0.7185	0.6546	0.6052	0.5983	0.5877
	Tau_b	0.4469	0.4484	0.4541	0.4438	0.4284
	Rho	0.5337	0.5344	0.5421	0.5052	0.4929
Age 40 - 44	Gamma	0.6732	0.6215	0.6229	0.5712	0.5209
	Tau_b	0.4332	0.453	0.4782	0.4214	0.3944
	Rho	0.5439	0.5591	0.5601	0.4884	0.4624
Age 50 - 54	Gamma	0.6485	0.6222	0.6044	0.5462	
	Tau_b	0.4513	0.4727	0.4548	0.4111	
	Rho	0.5402	0.5609	0.5387	0.489	

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population and the 2010 American Community Survey

Table 2.2: Log Odds Ratios for Whites by Cohort (Wives aged 30-34)

Husbands' Educational Attainment	Wives' Educational Attainment HSD, HS	HS, SC	SC, CG	CG, PC		Wives' Educational Attainment HSD, HS	HS, SC	SC, CG	CG, PC
1926-1930					1956-1960				
HSD, HS	0.589	0.179	0.107	-0.119	HSD, HS	0.744	0.125	0.217	-0.120
	(0.002)	(0.005)	(0.011)	(0.023)		(0.002)	(0.002)	(0.005)	(0.009)
HS, SC	0.140	0.507	0.061	-0.053	HS, SC	0.163	0.504	0.134	-0.046
	(0.004)	(0.005)	(0.009)	(0.019)		(0.002)	(0.001)	(0.002)	(0.004)
SC, CG	0.299	0.142	0.500	-0.101	SC, CG	0.288	0.203	0.621	-0.008
	(0.008)	(0.005)	(0.008)	(0.016)		(0.005)	(0.002)	(0.001)	(0.003)
CG, PC	0.006	0.220	0.024	0.485	CG, PC	-0.095	0.138	0.148	0.443
	(0.012)	(0.006)	(0.007)	(0.011)		(0.010)	(0.003)	(0.002)	(0.002)
1936-1940					1966-1970				
HSD, HS	0.624	0.142	0.030	-0.143	HSD, HS	0.897	0.192	0.258	-0.181
	(0.003)	(0.006)	(0.012)	(0.021)		(0.002)	(0.002)	(0.005)	(0.008)
HS, SC	0.152	0.495	0.078	-0.051	HS, SC	0.230	0.449	0.121	-0.008
	(0.005)	(0.004)	(0.008)	(0.016)		(0.003)	(0.001)	(0.002)	(0.003)
SC, CG	0.323	0.253	0.467	-0.101	SC, CG	0.175	0.130	0.622	0.068
	(0.009)	(0.005)	(0.007)	(0.014)		(0.006)	(0.002)	(0.002)	(0.002)
CG, PC	0.030	0.166	0.109	0.414	CG, PC	-0.170	0.052	0.125	0.448
	(0.013)	(0.006)	(0.006)	(0.009)		(0.010)	(0.003)	(0.002)	(0.002)
1946-1950					Younger (1960's) - Older (1920's) Cohort				
HSD, HS	0.752	0.130	0.167	-0.118	HSD, HS	**0.308**	**0.013**	**0.151**	**-0.063**
	(0.001)	(0.002)	(0.005)	(0.008)		**(0.003)**	**(0.005)**	**(0.012)**	**(0.024)**
HS, SC	0.179	0.535	0.062	0.043	HS, SC	**0.090**	**-0.058**	**0.060**	**0.045**
	(0.002)	(0.001)	(0.002)	(0.004)		**(0.005)**	**(0.005)**	**(0.009)**	**(0.020)**
SC, CG	0.360	0.219	0.510	-0.117	SC, CG	**-0.125**	**-0.012**	**0.122**	**0.169**
	(0.004)	(0.002)	(0.002)	(0.003)		**(0.010)**	**(0.006)**	**(0.008)**	**(0.017)**
CG, PC	-0.123	0.182	0.079	0.454	CG, PC	**-0.177**	**-0.169**	**0.101**	**-0.037**
	(0.006)	(0.002)	(0.002)	(0.002)		**(0.015)**	**(0.007)**	**(0.007)**	**(0.011)**

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population

Table 2.3: Log Odds Ratios for Blacks by Cohort (Wives aged 30-34)

Husbands' Educational Attainment	Wives' Educational Attainment HSD, HS	HS, SC	SC, CG	CG, PC		Wives' Educational Attainment HSD, HS	HS, SC	SC, CG	CG, PC
1926-1930					1956-1960				
HSD, HS	0.752	0.037	0.211	0.125	HSD, HS	0.606	0.077	0.130	0.004
	(0.010)	(0.018)	(0.031)	(0.056)		(0.006)	(0.006)	(0.012)	(0.029)
HS, SC	0.010	0.543	-0.187	0.105	HS, SC	0.108	0.594	0.074	0.172
	(0.019)	(0.023)	(0.036)	(0.059)		(0.008)	(0.004)	(0.006)	(0.013)
SC, CG	0.006	0.370	0.513	-0.120	SC, CG	-0.031	0.150	0.602	-0.016
	(0.043)	(0.037)	(0.039)	(0.060)		(0.018)	(0.008)	(0.006)	(0.010)
CG, PC	0.235	-0.184	0.161	0.411	CG, PC	-0.183	0.081	0.087	0.442
	(0.063)	(0.049)	(0.044)	(0.052)		(0.032)	(0.015)	(0.010)	(0.011)
1936-1940					1966-1970				
HSD, HS	0.656	0.078	0.129	0.038	HSD, HS	0.658	0.151	0.068	-0.067
	(0.009)	(0.014)	(0.030)	(0.050)		(0.008)	(0.007)	(0.014)	(0.027)
HS, SC	0.129	0.481	0.193	-0.257	HS, SC	0.088	0.565	0.123	0.100
	(0.018)	(0.017)	(0.028)	(0.048)		(0.009)	(0.004)	(0.005)	(0.010)
SC, CG	-0.006	0.207	0.516	-0.374	SC, CG	0.141	-0.016	0.593	0.061
	(0.040)	(0.030)	(0.032)	(0.064)		(0.019)	(0.006)	(0.006)	(0.009)
CG, PC	-0.012	0.075	-0.100	0.976	CG, PC	-0.115	-0.003	0.058	0.424
	(0.054)	(0.039)	(0.036)	(0.057)		(0.033)	(0.012)	(0.009)	(0.009)
1946-1950					Younger (1960's) - Older (1920's) Cohort				
HSD, HS	0.630	0.009	0.220	-0.080	HSD, HS	**-0.094**	**0.113**	**-0.143**	**-0.191**
	(0.004)	(0.005)	(0.012)	(0.018)		**(0.013)**	**(0.019)**	**(0.034)**	**(0.063)**
HS, SC	0.032	0.553	-0.005	0.148	HS, SC	**0.078**	**0.023**	**0.311**	**-0.006**
	(0.006)	(0.004)	(0.008)	(0.012)		**(0.021)**	**(0.023)**	**(0.036)**	**(0.059)**
SC, CG	0.225	0.167	0.527	-0.093	SC, CG	**0.135**	**-0.386**	**0.080**	**0.181**
	(0.016)	(0.008)	(0.008)	(0.011)		**(0.047)**	**(0.037)**	**(0.040)**	**(0.061)**
CG, PC	-0.149	0.174	-0.015	0.470	CG, PC	**-0.351**	**0.180**	**-0.103**	**0.012**
	(0.024)	(0.011)	(0.010)	(0.011)		**(0.071)**	**(0.051)**	**(0.045)**	**(0.052)**

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population

Table 2.4: Distribution of Wive's and Husband's Educations across Cohorts (Wives Aged 30-34)

	White						Black					
Husband's Educational Attaninment	Wives' Educational Attainment						Wives' Educational Attainment					
1926-1930	HSD	HS	SC	CG	PC	Total	HSD	HS	SC	CG	PC	Total
HSD	27.03	14.99	1.53	0.3	0.08	43.92	58.35	13.49	2.51	0.73	0.18	75.25
HS	8.3	17.86	2.75	0.69	0.14	29.73	5.59	7.3	1.48	0.7	0.23	15.3
SC	1.84	5.46	2.7	0.78	0.14	10.92	1.48	1.98	1.4	0.43	0.18	5.47
CG	0.57	3.37	2.31	2.11	0.3	8.67	0.28	0.38	0.63	0.63	0.2	2.11
PC	0.29	1.74	1.98	1.91	0.83	6.76	0.15	0.35	0.38	0.55	0.45	1.88
Total	38.03	43.41	11.27	5.79	1.5	100	65.85	23.5	6.39	3.03	1.23	100
N of Obs	45,254						3,988					
Homogamy	50.53						68.13					
1936-1940	HSD	HS	SC	CG	PC	Total	HSD	HS	SC	CG	PC	Total
HSD	16.75	11.69	1.13	0.29	0.11	29.98	36.27	16.54	2.76	0.58	0.24	56.4
HS	8.12	23.87	3.2	0.88	0.24	36.31	7.99	16.49	3.29	0.93	0.42	29.13
SC	1.72	7.18	3.01	0.99	0.24	13.14	1.3	3.61	2.18	0.96	0.24	8.28
CG	0.41	3.6	2.7	2.6	0.5	9.8	0.27	0.74	0.72	1.04	0.11	2.87
PC	0.27	2.54	2.79	3.45	1.72	10.76	0.24	0.64	0.74	0.85	0.85	3.32
Total	27.27	48.88	12.83	8.21	2.8	100	46.07	38.02	9.69	4.35	1.86	100
N of Obs	41,400						3,766					
Homogamy	47.95						56.83					
1946-1950	HSD	HS	SC	CG	PC	Total	HSD	HS	SC	CG	PC	Total
HSD	7.87	6.5	1	0.17	0.1	15.64	12.78	11.54	3.13	0.47	0.29	28.2
HS	4.8	22.4	4.65	1.16	0.52	33.53	5.94	22.9	6.34	1.58	0.81	37.56
SC	1.36	9.58	6.81	1.96	0.97	20.68	1.91	7.92	7.83	1.93	1.39	20.98
CG	0.23	3.71	4.37	4.07	1.54	13.92	0.22	1.53	2.22	1.84	1.07	6.88
PC	0.19	2.31	4.14	4.62	4.97	16.23	0.16	0.79	1.71	1.37	2.35	6.37
Total	14.46	44.5	20.96	11.98	8.09	100	21	44.67	21.23	7.19	5.9	100
N of Obs	280,480						22,982					
Homogamy	46.12						47.7					
1956-1960	HSD	HS	SC	CG	PC	Total	HSD	HS	SC	CG	PC	Total
HSD	3.44	3.87	1.34	0.17	0.06	8.88	4.49	6.04	2.74	0.45	0.08	13.8
HS	3.04	18.99	8.76	1.83	0.49	33.1	3.85	20.89	11.32	2.51	0.45	39.01
SC	1.08	9.82	14.45	4.11	0.99	30.45	1.15	8	17.01	4.47	1.19	31.82
CG	0.15	2.65	6.22	7.4	1.75	18.16	0.21	1.36	4.08	4.29	1.1	11.03
PC	0.05	0.71	2.29	3.83	2.51	9.4	0.08	0.34	1.23	1.58	1.12	4.34
Total	7.76	36.03	33.06	17.34	5.8	100	9.78	36.63	36.37	13.3	3.93	100
N of Obs	298,470						20,533					
Homogamy	46.79						47.8					
1966-1970	HSD	HS	SC	CG	PC	Total	HSD	HS	SC	CG	PC	Total
HSD	3.44	3.66	1.01	0.23	0.09	8.43	2.21	4.05	1.24	0.31	0.08	7.89
HS	2.61	21.92	9.41	3.88	1	38.82	3.38	28.16	12.2	3.57	0.79	48.11
SC	0.51	7.27	8.77	4.78	1.21	22.54	0.74	7.55	12.02	4.67	1.3	26.27
CG	0.13	2.77	4.51	10.3	3.05	20.75	0.16	2.26	3.47	5.28	1.69	12.86
PC	0.05	0.72	1.32	4.02	3.34	9.46	0.06	0.65	0.99	1.72	1.46	4.88
Total	6.74	36.35	25.01	23.2	8.69	100	6.55	42.66	29.92	15.55	5.33	100
N of Obs	229,973						18,133					
Homogamy	47.77						49.13					

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population

Table 2.5: Proportions of Marrying Up, Down, and Homogamously by Cohort (Wives Aged 30-34)

	HSD	HS	SC	CG	PC	Total in level
Whites						
Up						
1926-30	28.92	24.33	38.07	32.99	-	27.76
1936-40	38.58	27.25	42.79	42.02	-	32.78
1946-50	45.57	35.06	40.55	38.56	-	35.31
1956-60	55.67	36.55	25.74	22.09	-	29.83
1966-70	48.96	29.63	23.27	17.33	-	23.91
Homogamous						
1926-30	71.08	41.14	23.96	36.44	55.33	50.53
1936-40	61.42	48.83	23.46	31.67	61.43	47.95
1946-50	54.43	50.34	32.49	33.97	61.43	46.12
1956-60	44.33	52.71	43.71	42.68	43.28	46.79
1966-70	51.04	60.30	35.07	44.40	38.43	47.77
Down						
1926-30	-	34.53	37.98	30.57	44.00	21.70
1936-40	-	23.92	33.75	26.31	38.93	19.27
1946-50	-	14.61	26.96	27.46	38.69	18.57
1956-60	-	10.74	30.55	35.24	56.72	23.37
1966-70	-	10.07	41.66	38.32	61.57	28.32
Blacks						
	HSD	HS	SC	CG	PC	Total in level
Up						
1960	11.39	11.53	15.65	18.15	-	11.76
1970	21.27	13.12	15.07	19.54	-	17.10
1980	39.14	22.90	18.51	19.05	-	23.75
1990	54.09	26.48	14.57	11.88	-	21.87
2000	66.26	24.50	14.91	11.06	-	20.97
Homogamous						
1960	88.61	31.06	21.91	20.79	36.59	68.13
1970	78.73	43.37	22.50	23.91	45.70	56.83
1980	60.86	51.26	36.88	25.59	39.83	47.70
1990	45.91	57.03	46.77	32.26	28.50	47.80
2000	33.74	66.01	40.17	33.95	27.39	49.13
Down						
1960	-	57.40	62.44	61.39	64.23	20.13
1970	-	43.50	62.44	56.78	54.30	26.07
1980	-	25.83	44.61	55.35	60.34	28.55
1990	-	16.49	38.66	55.86	71.76	30.35
2000	-	9.49	44.92	54.98	72.42	29.90

Notes - Data are derived from 1960, 1970, 1980, 1990, and 2000 American Censuses of Population

Chapter 3

Reassessing the Effects of Catholic Schooling

3.1 Introduction

Several empirical studies have attempted to assess whether private schools provide better education than public schools. This question is crucial in the debate on public versus private schools and, more generally, on the effectiveness of school choice. Advocates of school competition and vouchers often rely on research evidence suggesting positive effects of private schooling on educational outcomes. Most researchers have focused their attention on the role of Catholic schools, which account for the largest share of private schools, analyzing their performance and effectiveness. There is a substantial consensus on the positive correlations between Catholic school attendance and educational outcomes. However, a causal interpretation of these findings has been severely limited by the spurious correlation between Catholic school attendance and other unobserved characteristics that may affect educational outcomes.

Most previous studies attempted to estimate the effects of Catholic schooling on student outcomes using different instrumental variables strategies (e.g., religious affiliation,

distance from the Catholic schools, density of Catholic population), and found evidence of positive effects of Catholic schooling on high school graduation and college attendance rates (Coleman et al., 1982; Neal, 1997; Evans and Schwab, 1995). More recently, Altonji et al. (2005b) cast doubt on the exclusion restrictions for the proposed instruments. The authors of that study used a different method based on the idea that selection on the observed characteristics provides a measure of the potential selection on the unobservables. Following this approach, they found positive effects of Catholic schooling on high school graduation and college attendance, but their results suggest smaller effects than previous studies and no evidence of significant effects on test scores. Adopting similar techniques, Elder and Jepsen (2013) find evidence of negative effects of Catholic primary schooling on math scores. Cohen-Zada and Elder (2009) proposed an alternative instrument based on the historical Catholic concentration in a county. They argued that historical Catholic shares are much more likely to be exogenous to student outcomes than previous instruments used in the literature. Their results are similar to those of Altonji et al. (2005b). Yet, a potential omitted variable bias may still exist if historical shares are correlated with other unobservable characteristics of the local area, such as private competition or local population density.

We contribute to the literature using a new strategy. With the universal call to holiness and the opening to lay leadership, the Second Vatican Council (Vatican II) in the early 1960s inadvertently produced a dramatic change in the cost/benefit ratio of religious life and drained Catholic schools of critical human capital. Between 1966 and 1980, the number of Catholic sisters (nuns) was reduced by more than 30%. This unexpected collapse was followed by a parallel decline in the number of Catholic schools in operation.

Following the decline in the number of Catholic sisters, the share of religious teachers in Catholic schools fell by more than 50%. Because religious teachers were paid, on average, one-third the amount that lay teachers were paid, the sudden and rapid shift in personnel imposed severe financial constraints on Catholic schools and forced many schools to close. The closure of Catholic schools was mostly caused by supply effects and was not driven by changes in the demand for Catholic schooling (Caruso, 2012). The decline in the supply of Catholic sisters was also more marked in dioceses that were more exposed to the reforms that occurred at the Second Vatican Council (Stark and Finke, 2000). We argue that the heterogeneity in the decline in vocations is partially explained by the unpredictable reactions of local bishops to the "religious earthquake" occurring in Rome. We use the sudden shock to the supply of Catholic sisters and its heterogeneous impact across US dioceses as an exogenous instrument for Catholic schooling. This approach allows us to control for both local area fixed effects, which account for time-invariant characteristics, and cohort fixed effects, which capture any systematic difference in school outcomes across cohorts. At the same time, we control for a set of local-area time-varying characteristics. In addition, the focus of the extant literature has been on the effectiveness of Catholic high schools. However, little is known about the effectiveness of Catholic primary schools. This paper focuses on the effects of Catholic schooling on grade repetition of students aged 7-15 years of age, and contributes to a recent set of studies on the effectiveness of Catholic primary schools (Elder and Jepsen, 2013; Gibbons and Silva, 2011; Reardon et al., 2009; Lubienski et al., 2009; Carbonaro, 2006). To conduct this analysis, we assembled a unique dataset based on the diocesan records of Catholic sisters, priests, and schools from 1960 to 1980, which was drawn from the Official Catholic Directory (OCD). We use these

data to document the trends in the human assets of the Catholic Church and Catholic schools before and after the Second Vatican Council. Using voting records from Vatican II collected by Wilde (2007) to classify the bishops into progressive and conservative categories, we provide evidence that the change in the number of sisters per Catholic diocese was more pronounced in dioceses governed by liberal bishops. We then merge the diocesan data with US Census information for different cohorts of students who were in school between 1960 and 1980. The US Census data contain individual information on parochial school attendance for individuals enrolled in school at the time of the census.[1] While these data do not contain information on test scores, we can use the information on educational attainment to analyze the effects of Catholic schooling on grade repetition. Our results show that the rapid decline in vocations was associated with a significant decline in Catholic schooling despite an increase in the Catholic population resulting from new immigrant inflows. In particular, a one standard deviation decrease in the number of Catholic sisters in a metropolitan statistical area (MSA) is associated with a 14% reduction in a student's likelihood of attending a Catholic school. We provide evidence that our instrument is more likely to be exogenous than the alternative instrumental variable strategies previously used in the literature. Turning to the analysis of the effects of Catholic schooling on educational performance, ordinary least squares (OLS) estimates confirm a positive relationship between attending a Catholic school and school outcomes. However, using the number of Catholic sisters in a given cohort-MSA as an instrument for Catholic

[1] The U.S. Census does not identify the religious denomination of the school, only whether the school was a "parochial" or "church-related" school. However, the vast majority of private schools over the period considered in the paper were Catholic schools (Kim, 2011). Of course, this is even more pronounced when restricting the analysis to parochial schools. Therefore, we will use parochial and Catholic schools interchangeably.

schooling, we do not find evidence of significant effects on grade repetition and reject the OLS estimates; if anything, we find evidence of negative effects. These results suggest that the OLS estimates are entirely driven by a positive selection bias. To verify the plausibility of our results, we also use the techniques of Altonji et al. (2005b) and show that even a modest degree of selection on unobservables is sufficient to eliminate and reverse the sign of Catholic schooling. When examining different measures of educational attainment (high school dropout rates, high school graduation rates, and the rate of college attendance) using reduced-form relationships, we find no evidence of positive effects. Finally, we discuss whether the sudden shock to the number of religious teachers affects the validity of our identification strategy by changing the average quality of surviving Catholic schools. Focusing on children attending Catholic schools, we provide evidence that the share of religious teachers was negatively associated with grade repetition. If the prior assumption is that the higher quality of Catholic sisters had a significant and positive impact on student school outcomes, we should expect our reduced-form coefficient to be upward-biased. Because we find a null or negative effect, we interpret our two stage least squares (2SLS) estimate as plausibly identifying an upper bound on the Catholic school effects on student outcomes.

The paper is organized as follows. Section 2 provides a brief description of the Second Vatican Council and its causes and consequences. In Section 3, we describe the identification strategy and the data. The results are presented and discussed in Section 4. Section 5 concludes.

3.2 The Second Vatican Council and the Decline in Vocations

Less than three months after his election, Pope John XXIII announced his decision to convene a new Council in Rome to "open the windows of the Church and let some fresh air in". Given that the Conclave elected Angelo Roncalli, nearly eighty years old, in the context of a transitional pontificate, no one expected this to happen. The surprising decision to call a new Vatican Council was undertaken by the pope alone, exercising his papal primacy. Alberigo (2006), one of the most qualified historians to comment on Vatican II, starts his brief history of the Second Vatican Council by remarking how the pope's announcement "was unexpected and surprising for most sectors of the Church, which were dominated by the climate of the Cold War and satisfied with a Catholicism unyielding its certainties".[2] The purpose of the Council was to "recognize the signs of times" and to discuss and update the major features of Catholic doctrine and practice. For the purposes of this paper, it is important to note that most scholars emphasize the exogenoeity of the popes announcement. Not only was the Curia caught by surprise, but even liberal scholars and Council reformers, such as Alberigo, did not expect the pope to convene all of the bishops in Rome to renew and update the Church's beliefs, liturgies and practices (Stark and Finke, 2000; Berman et al., 2012). These changes had important practical and theological consequences for the life of the entire Catholic Church, starting with the life of religious men and women. Stark and Finke (2000) explain in depth how three Vatican II documents (Lumen Gentium, Gaudium et Spes and the Perfectae Caritatis) involved

[2] As reported in Alberigo (2006), the pope himself later acknowledged in the Journal of Soul that the Vatican Council was entirely the pope's initiative.

important changes to religious life. In particular, by establishing the universal call to holiness, the Lumen Gentium helped overcome the notion of the superior holiness of the religious state and gave new importance to the role of lay people in the Church. Overall, the Second Vatican Council emphasized the need of the Church to recognize "what changes with the passing of time" and to open itself to the modern world. Stark and Finke (2000) and Berman et al. (2012) note how these changes unintentionally affected the marginal benefits of a religious life by eliminating the superiority of religious status without substantially reducing the costs of a religious life, such as the vows of celibacy and poverty. The changes in the cost-benefit ratio of a religious life were marginally higher for women. Indeed, the Vatican II did not bring any progress to the ordination of women in the Church and de facto equiparated Catholic sisters to lay women in their path to "holiness". The loss of this special status contributed to the large decline in the late 1960s and early 1970s in the number of religious women. Scholars agree that these shocks in the life of the Catholic Church were the primary causes of the unexpected decline in vocations and the rise in defections. However, the debate on the mechanism underlying these patterns persists, with liberals arguing that priests and nuns left the Church because they had been hoping for more extensive reforms and conservatives blaming the Church's excessive modernization and the universal call to holiness for the decline in vocations (Ebaugh, 1993; Stark and Finke, 2000). Like Berman et al. (2012), who use the natural experiment provided by the Second Vatican Council and the decline in female vocations to explain fertility patterns in Europe, we do not focus directly on the causes of the decline.[3] We

[3]The researchers use a panel on church attendance and clergy employment for the years 1960-2000 and show evidence that the interaction of the service provision and religiosity largely explains the declining fertility observed in Southern Europe. In particular, they show that their results are consistent with a model in which social service provided by the Church affects fertility by lowering the cost of raising children.

are simply interested in establishing the exogeneity of the shock to the supply of Catholic sisters and its validity as an instrument for studying the effects of Catholic schooling. In particular, it is important to establish that this shock was exogenous and not related to individual unobservable characteristics that may affect both Catholic schooling and student outcomes. The obvious concern when using a historical event as a natural experiment is that there may have been several other factors affecting Vatican II that may explain the trends in vocations and be endogenous to the outcome of interest. One could think that female religious vocations decreased because of the expanded opportunities for women. Stark and Finke (2000) argue that the timing of the collapse in vocations suggests that other factors, such as trends in income and female labor force participation, played only minor roles in explaining the abrupt reduction in the number of Catholic sisters. After World War II, female labor force participation and income grew slowly and steadily. On the contrary, as shown in Figure 3.1, there was a steady growth in the number of nuns until the mid 1960s, followed by a rapid decline thereafter. We further discuss the validity of our identification strategy in the next section.

3.3 Data and Empirical Specification

We use data from three main sources: the US diocesan records contained in the Official Catholic Directory; the records of votes expressed at the Second Vatican Council, collected by Wilde (2007); and individual data drawn from the US Census (1970 and 1980) containing information on parochial school attendance and educational attainment. The Official Catholic Directory (OCD) was first published in 1817 by P.J. Kennedy & Sons and contains detailed annual statistics on American dioceses, including the number of

priests and nuns serving the dioceses, and the number of seminarians, Catholic schools, and religious and lay teachers. We collected data for the years 1960 to 1980 for each US diocese.To be able to conduct a consistent analysis over time and across US dioceses, we constructed a balanced panel of dioceses for which we have information available for every year 1960 to 1980. In cases where new dioceses were created, we aggregated the information to reconstruct the original set of dioceses. In the few cases in which a new diocese was created by merging the territories of two or more dioceses, we attributed the numbers of the new diocese to the major contributing diocese.[4] After performing these adjustments, we were left with a panel of 122 dioceses for which we had consistent information for the period between 1960-1980.[5]

3.3.1 Catholic Sisters and Parochial Schools Before and After the Second Vatican Council

Figure 3.1 shows the pattern of vocations and changes in the staff composition in Catholic schools over time. As previously noted, in the years preceding the Second Vatican Council, there was substantial and steady growth in the number of nuns and more moderate growth in the number of Catholic priests. The increase in the number of nuns was accompanied by an expansion of the Catholic school system in the US, which was reflected in the growth of sisters and lay teachers. However, in the years immediately following the Second Vatican Council, we observe a sharp decline in the number of nuns. This decline is only partially compensated for by the increase in the number of lay teachers in Catholic schools. The number of Catholic sisters reached a peak of approximately 180,000 in 1966 and then

[4]When using alternative criteria such as excluding these dioceses from our analysis, our results were not substantially changed.

[5]We excluded from the analysis the Vicariate Apostolic of Alaska, the Belmont Abbey, the Byzantine Rite and the Pittsburgh (Greek Rite) diocese.

fell dramatically to approximately 125,000 in 1980 (-30%).[6] During the same period, the number of lay teachers increased significantly (+56%). However, this increase could not compensate for the decline in the number of sisters who were teachers.[7] Catholic sisters accounted for 60% of the total number of teachers in 1960 but for less than 25% in 1980. Because religious teachers were, on average, paid one third the amount that lay teachers were paid, the dramatic collapse of female vocations had an immediate impact on tuitions and the ability of parishes to keep their schools open by replacing former religious teachers with lay teachers.[8] Figure 3.2 illustrates how the trends in Catholic schools across US dioceses closely resemble the trends in female religious vocations. Between 1965 and 1980, the number of parochial high schools declined by approximately 40% and parochial elementary schools by 35%. It is worth noting that the decline in the number of Catholic schools occurred in a context of the "voracious demand of families for Catholic schools",

[6]Ebaugh (1993) remarks how the sharp decline in the number of Catholic sisters between 1966 and 1986 was due to both a decrease in the rate of entry and an increase in defections. The shortage of new vocations and the fact that the majority of those defecting were under the age of 40 dramatically affected the age structure within the religious orders. Within a few years, the percentage of sisters over 65 years of age doubled from 17% in 1966 to 38% in 1982 (Neal, 1984).

[7]Interestingly, the absolute number of priests remained relatively stable over the evaluated period of time. However, after normalizing by the size of the Catholic population, the decline followed a similar, although less marked, pattern. This is consistent with the idea suggested by Stark and Finke (2000) that the changes occurring at the Second Vatican Council were particularly devastating for women who, "unlike males, had never been granted ordination, and now their holiness was reduced to that of all other lay Catholics".

[8]Differences in the extent of the vow of poverty and the congregational needs reflected different salaries across congregations and schools. Unfortunately, we did not find more precise data regarding religious women's salaries. However, Finke and Stark (2005) emphasize that religious women's salaries were not only lower than those of public school teachers but also lower than those of religious brothers who were teachers. We found more information regarding the salaries paid to lay teachers (see Hesburgh et al. (1966), which were also lower than those paid to public school teacher, but still approximately three times higher, on average, than salaries paid to Catholic sisters. Koob and Shaw (1970) report than in the late 1960s, lay teachers' salaries in many dioceses were set at 90-95% of public school salaries. The increased need for lay teachers forced Catholic schools to provide more competitive salaries to attract trained teachers. The gap between religious and lay teacher salaries shrank over the most recent years, likely due to the increasing financial difficulties facing religious congregations (Fialka, 2003). In 2009, however, a religious teacher was paid, on average (30,806$), approximately 4,000$ less than a lay teacher (34,656$) in a Catholic school. Additionally, less than 30% of the schools applied the same rate to the two categories of teachers.

as noted by Caruso (2012). The closure of Catholic schools was largely the result of supply effects. Without nuns to staff schools, Catholic schools were forced to hire lay teachers and pay competitive salaries to meet demand. The increase in the share of lay teachers became financially unbearable, forcing schools to increase their tuition fees or to close (Caruso, 2012; Dolan, 1992; Bryk et al., 1993).

3.3.2 Heterogeneity Across US Dioceses

The decline in female religious vocations was heterogeneous across the different dioceses. Scholars speculated that the variation in the decline across US dioceses can be partially explained by variation in the receptiveness of the dioceses to Vatican II reforms. With the help of a group of experts, Stark and Finke (2000) classified dioceses to identify those that were most traditional and progressive. They showed that liberal dioceses faced a sharper decline in religious vocations in the aftermath of Vatican II. We take a different approach and use the voting records of Bishops at Vatican II to classify progressive and conservative bishops. Wilde (2007) obtained Council votes from the Vatican Secret Archive (Archivio Segreto Vaticano) and entered them into an electronic database that is now publicly available on the ARDA website. The voting data contain information on individual bishops, their dioceses and their votes on ten of the most contentious Council reforms. As suggested by Wilde (2007), we use the vote on the document "On the Sources of Revelation" as a measure of the Bishops openness to change. "On the Sources of Revelation" is a particularly conservative document refuting the historical and anthropological contextualization of the Bible and emphasizing the importance of Church "tradition" with respect to the scripture-centered protestant culture. Because most of the bishops who expressed liberal views in the other votes opposed this document, we define a bishop as liberal if he voted

against it. In cases where two or more bishops participating at the Council resided in the same diocese, we averaged the votes and considered the dioceses where the votes where tied to be conservative.[9] Figure 3.3 and Table 3.1 provide evidence that the change in the number of sisters per Catholic school was more pronounced in liberal dioceses. In Figure 3.3, we show how the number of Catholic sisters, sister teachers, parochial elementary schools and high schools follow a similar pattern. However, the decline following Vatican II occurred at a faster rate in liberal dioceses (solid line in the graphs). Table 3.1 shows that, accounting for persistent differences in the dioceses and time fixed effects, the fall in the number of Catholic sisters per Catholic was 11% lower in conservative dioceses than in liberal dioceses (see column 1). Column 2 reports a similar pattern when we look at the number of sister teachers. The difference in the rate of decline is more evident when we focus on the most conservative dioceses as classified by Stark and Finke (2000) (see columns 3 and 4).[10] For these dioceses, the decline was approximately 65% lower than what we observed for the more liberal dioceses. The evidence presented suggests that the heterogeneity in the decline of vocations was partially explained by the reactions of bishops to the "religious earthquake" occurring in Rome. Moreover, the votes of bishops at the Second Vatican Council and, more generally, their attitudes toward the unexpected reforms were largely unpredictable at the beginning of the Council (Alberigo, 2006; Wilde, 2007). Taken together, this analysis strengthens our belief that the variation in the decline in the number of Catholic sisters was exogenous to unobservable time-varying diocesan

[9] Alternatively, we considered only the vote of the residential bishop and found no significant differences in the main results.

[10] When comparing the most conservative and most liberal dioceses, we adopted the same categorization used by Stark and Finke (2000), who asked a group of experts to identify the ten most traditional and the ten most liberal dioceses. We consider the following dioceses to be traditional: Lincoln, Arlington, Bridgeport, Scranton, St. Louis, and Camden. We consider the following dioceses to be the most liberal: Saginaw, New Ulm, Albany, Milwaukee, Joliet, San Francisco, Rochester, and Richmond.

characteristics that may have been correlated with both the drop in the number of nuns and student outcomes. Under this identifying assumption, we exploit the sudden shock to the supply of Catholic sisters and its heterogeneous impact across US dioceses as an exogenous instrument for parochial schooling.

3.3.3 Identification Strategy

Figure 3.4 illustrates the heterogeneity in the decline in the number of Catholic sisters and parochial schools across US states in the aftermath of Vatican II. Our identification follows a difference-in-difference approach, exploiting the variation in the availability of Catholic sisters across US Census Metropolitan Statistical Areas (MSAs) between 1960 and 1980, covering the years preceding and following the Second Vatican Council. We merged the panel of US dioceses with the 1% US Census Sample of 1970 and the 5% US Census Sample of 1980.[11] Following the previous literature (Lankford and Lee, 1995), we assigned to each MSA the diocesan characteristics of the dioceses contained in the MSA.[12] Averages across dioceses were used whenever an MSA included counties from more than one diocese. As a robustness check, we collected data at the county level for the four largest dioceses (Chicago, Detroit, Los Angeles, and New York) and merged them with the US census data at the county-level. The US Census does not contain information on Catholic schooling but it does contain information on parochial and private schooling attendance.[13] We focus on the population of children between 7 and 15 years of age, who were the most likely to live with their parents and therefore who were more likely to be represented in

[11] The results are identical using the 1% sample for both years.

[12] To match dioceses and MSAs, we relied on the county composition of the diocese.

[13] According to the National Center for Education Statistics, approximately 80% of the total number of private schools in existence in the 1950s were Catholic (see also Kim (2011)).

the sample. Focusing on this group allows us to use the information on current enrolment in a parochial or public school in the census year. US Census data contain only limited information on children's outcomes. However, grade retention can be computed using information on educational attainment and age. Grade retention has been shown to be significantly correlated with other measures of educational performance (Oreopoulos et al., 2006; Shepard and Smith, 1989). As in Oreopoulos et al. (2006), we define the likelihood of repeating a grade with a dummy variable of a value of one if a student is one grade behind the median grade by state, sex, quarter of birth and age. This measure of grade retention includes students who delayed entry into the school system and therefore it is, more accurately, a measure of grade-for-age.[14] We compare cohorts of students who were 7-15 years old at the time of the 1970 US Census and entered school between 1961 and 1969 to the outcomes of students who were 7-15 years old at the time of the 1980 US Census and entered school between 1971 and 1979. This allows us to compare different cohorts of students living in the same areas and to control for both local area fixed effects, which account for time invariant characteristics, and cohort fixed effects, which capture systematic differences in school outcomes within a given cohort. Furthermore, we control for a set of time-varying characteristics of the MSA (e.g., current density of Catholic population, female labor force participation, population density, and teacher's education) that may be correlated with both the number of Catholic sisters and grade repetition. We restrict the sample to children living in identifiable MSA's, with no missing information on parental education and family income. After setting these restrictions, the sample

[14] Alternatively, we measure grade retention by treating all children who turned 6 before October 1 as if they had entered first grade in the autumn of that year and children who turned 6 after October 1 as though they had entered school the following year. Our main results are substantially unchanged.

included 841,958 children. We estimate the following linear probability model[15]:

$$P_{imt} = \beta_0 + \theta N_{mt} + \beta_1 X_{imt} + \beta_2 D_{mt} + \tau_t + \lambda_m + u_{imt} \tag{3.1}$$

where P_{imt} is a dummy variable indicating whether individual i of birth cohort t goes to a parochial school in MSA m.[16] N_{mt} denotes a measure of average exposure to Catholic sisters who are teachers throughout the schooling years of an individual i in MSA m. Henceforth, we will use Catholic sisters to refer to Catholic sisters teaching in Catholic schools.[17] This measure variates by birth cohort (we computed the starting school year based on quarter of birth and age) and MSA. For example, if a 10-year-old student is observed in the 1970 Census in MSA m, he will be assigned the average number of Catholic sisters in MSA m between 1967 and 1970.[18] D_{mt} are MSA time-varying characteristics. X_i are standard socio-demographic controls. τ_t and λ_m are cohort and MSA fixed effects. To analyze the effects on school outcomes, we estimate the following model:

$$Y_{imt} = \alpha_0 + \alpha_1 P_{imt} + \gamma_1 X_{imt} + \gamma_2 D_{mt} + \tau_t + \lambda_m + \epsilon_{imt} \tag{3.2}$$

where Y_{imt} is an indicator of grade retention. In practice, we exploit within-MSA differences in the availability of Catholic sisters that created exogenous shifts in the likelihood of attending a parochial school to analyze the effects of Catholic schooling on grade repetition. We believe that conditioning on MSA time- varying characteristics and controlling

[15] As a robustness check, we estimate probit models for our main estimates. The results are substantially unchanged and available upon requests.

[16] As mentioned earlier, MSA-level data for Catholic sisters, teachers and the Catholic population were computed using diocesan data. Therefore, the term diocese and MSA will be used interchangeably in this paper.

[17] We alternatively use the total number of sisters (including those who were not teachers) in the diocese. The results flow in the same direction, as the two metrics are strongly correlated.

[18] We followed the same method to compute analogue measures of exposure to lay teachers and total teachers in Catholic schools, Catholic schools, and Catholic population in the MSA.

for MSAs and cohort fixed effects shows that the sudden and sharp decline in the number of Catholic sisters that induced Catholic school closures across the country is an exogenous shock to Catholic schooling.[19]

3.3.4 Evidence for the Exogeneity of the Instrument

In an attempt to assess the validity of our instrumental strategy, in Table 3.2, we analyze the correlation between our instrument and individual observable characteristics (column 3). We then compare the coefficients reported in column 3 to the ones observed when considering the most recent instrument used in the literature (Cohen-Zada and Elder (2009), column 4) and the simple parochial schooling indicator (column 5). Columns 1 and 2 report the summary statistics of the main individual observables. In column 3, we present the standardized coefficients of separate regressions of the variables listed in the first column on the number of Catholic sisters, controlling for MSA and cohort fixed effects. In column 4, we repeat the same exercise for the instrumental variable proposed by Cohen-Zada and Elder (2009) and look at the relationship between observables and the historical share of Catholic population.[20] We restrict the sample to 1980 and condition each regression for state fixed effects and current Catholic population to mimic the empirical strategy used by Cohen-Zada and Elder (2009). Finally, in column 5, we analyze the relationship between parochial schooling and the other observable characteristics. Column

[19] A potential concern is that grade retention policies may be different across Catholic and public schools. As we use a difference-in-difference approach, our identification strategy is not affected by persistent differences between the two types of schools. One could still be concerned that grade retention policies were correlated with the changes in the supply of religious teachers. However, it is worth noting that while the number of Catholic sisters teaching in schools declined dramatically, the school administration and direction remained largely in the hands of religious staff (Caruso, 2012).

[20] Data on the share of Catholic population in 1980 are drawn from the Religious Congregation and Membership in the United States, while data for 1890 were taken from the American Religion Data Archive and originally collected by the US Census of Religious Bodies.

5 confirms the significant selection on observable characteristics with parochial schooling associated with higher parental education, higher income and lower likelihood of minority status. The average number of Catholic sisters (column 3) is positively correlated with family income and parental education, suggesting some selection bias. As socio-economic status is positively associated with student outcomes, this may bias our estimates upward, which should therefore be interpreted as an upper bound. Family income and parental education are included as controls in all of our regressions. However, the coefficients on the other observables are non-significant. Furthermore, the absolute value of the coefficients is always lower with respect to the correlation between observables and both Catholic schooling (column 5) and the historical share of Catholics in the county (column 4). While this does not rule out that our estimates may still suffer from spurious correlation between unobservables and our instrument, Table 3.2 suggests that our instrumental variable may be less likely to suffer from selection on unobservables.

3.4 Main Results

3.4.1 Catholic School Supply and Catholic Schooling

Table 3.3 illustrates the estimates for equations 3.1 (column 1) and 3.2 (columns 2-4). Each regression controls for a set of a child's characteristics, gender, race, Hispanic ethnicity, birth quarter, age dummies), family background (maternal and paternal age dummies, maternal and paternal education (4 groups), family income, MSA and cohort fixed effects, and a set of MSA time-varying characteristics, female labor force participation, teachers' education and Catholic population.[21] We include a quadratic trend in all of our esti-

[21] Adding to this specification, teacher experience and the logarithm of teacher wages do not change the point estimate, but they do reduce the precision of our estimate. Female labor force participation

mates. Standard errors are clustered at the MSA level. Column 1 reports the estimate of our first-stage regression. There is a positive and significant association between attending a parochial school and the number of sisters available in the different dioceses. The coefficient implies that a one standard deviation increase in the number of Catholic sisters (789.12) is associated with a 14% increase in the likelihood of attending a parochial school. The F-statistic of the first-stage is 14.84. We now move to the examination of the relationship between Catholic schooling and grade repetition. Column 2 reports the OLS estimate. Attending a parochial school is associated with an 11% reduction in the likelihood of repeating a grade. This finding is in line with previous evidence of a positive correlation between Catholic schooling and school outcomes. However, instrumenting parochial schooling with the cohort-MSA measure of exposure to Catholic sisters does not lead to evidence of significant effects on grade repetition. Column 3 reports the reduced form showing no significant relationship between the availability of nuns and the likelihood of repeating a grade.[22] The 2SLS estimate (column 4) is also non-significant and, if anything, suggests a negative (positive) effect of Catholic schooling on school outcomes (grade repetition). Although the standard errors are large, we reject the OLS estimate.[23][24]

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and teacher education vary by census year. The female labor force participation rate in each MSA is calculated by dividing the number of employed women aged 15-64 by the total female population of the same age group. Teachers in each MSA were identified by industry (professional and related services - elementary and secondary schools) and occupation (elementary and secondary school teachers). The Catholic population is drawn from the Official Catholic Directory.

[22] Following (Altonji et al., 2005a), we also assessed the reduced-form relationship between the instrument and outcomes for public school students. We find no evidence of a significant effects when focusing on public school students (coef. 0.004, s.e. 0.005).

[23] The Hausman test rejects the equality of the coefficients at the 10% level on the overall sample and at the 5% level when we restrict the sample to whites.

[24] We examined the sensitivity of our main estimate to the inclusion of additional time-varying controls, regional time trends, and region-year fixed effects. Including time-varying MSA information on teachers' wages and experience does not significantly affect the point-estimate with respect to the baseline result reported in column 1. However, the precision of the estimate is clearly affected because these variables are correlated with teachers' education. Including region-specific cohort trends, the point-estimate does not change substantially, but the confidence interval increases. These results are available upon request.

3.4.2 Using County-Level Variation in Large Dioceses

In an attempt to obtain more precise estimates, we collected county level information on the number of Catholic sisters. While this information is available in the Official Catholic Directory, it requires an intensive data collection process as the within-diocese information is only available at the school level. For this reason, we only collected data at the school level for the four largest dioceses in the US (Chicago, Detroit, New York, and Los Angeles) which account for 14% of our original sample of students. We then aggregated the school-level information at the county level in order to merge it with the information available in the US Census.

Table 3.4 replicates the analysis presented in Table 3.3 using county-level variation in the number of Catholic sisters on this restricted sample of dioceses. In practice, we estimate equation 3.2 replacing MSA fixed effects and time-varying characteristics with county fixed effects and time-varying controls. Standard errors are clustered at the MSA level.[25] Column 1 shows that one standard deviation in the number of Catholic sisters increases Catholic schooling by 35%. The OLS and the reduced form coefficients (columns 2 and 3) on grade retention are substantially identical to the ones observed in Table 3.3. The 2SLS estimate in column 4 implies that Catholic schooling increases the likelihood of repeating the grade by 10 percentage points. Using county-level variation in the number of Catholic sisters we obtain a more precise estimate of the effect that the one presented in Table 3.3. Overall, the estimates presented in Table 3.4 confirm that the OLS relation is entirely explained by selection and that, if anything, Catholic schooling increases grade

[25] Note that in a previous version of the paper standard errors were clustered at the county level. However, the significance of the results is not affected.

retention.

3.4.3 Is the Selection Implied by Our Results Plausible?

The above findings suggest that the OLS estimates are driven by positive selection bias. To verify the plausibility of our results, we use the techniques of Altonji et al. (2005b) and exploit the information about selection on the observables to gauge the role of selection bias and verify whether our IV estimates are consistent with it. In particular, in Table 3.5, we jointly estimate the following system of equations:

$$P = 1(X'\beta + u > 0),$$

$$Y = 1(X'\gamma + \alpha P + \epsilon > 0)$$

We impose different values for ρ, the correlation between the error terms of the above equations. Column 1 (ρ=0) presents the single-equation estimates. The marginal effect is substantially identical to the OLS estimate presented in Table 3.3, column 2. In columns 2-7 we illustrate how a modest amount of positive selection (small negative correlation between ϵ and u) is sufficient to explain away the positive effect of Catholic schooling and even reverse the sign. Column 8 reports the estimates obtained assuming that selection on the observables equals selection on unobservables. In other words, we assume that the projection of P on ϵ equals its projection on the index of other determinants of Y: $\frac{Cov(P,\epsilon)}{Var(\epsilon)} = \frac{Cov(P,X'\gamma)}{Var(X'\gamma)}$. Altonji et al. (2005b) justify the equal selection assumption by arguing that for large datasets used for different purposes, the available information can be thought of as a random subset of the determinants of a particular outcome under

study.[26] Following this approach, we identify a lower bound for the effects of Catholic schooling. In practice, we estimate a bivariate probit model and maximize the likelihood imposing $\rho = \frac{Cov(X'\beta, X'\gamma)}{Var(X'\gamma)}$. The estimate of α implies a large and negative effect of parochial schooling on grade repetition. Under the assumption of equality of selection on observables and unobservables, the strong and positive (negative) correlation between observable determinants of student outcomes (grade repetition) and Catholic schooling results in a strong and positive correlation with the unobservables, implying a large positive bias in OLS. In other words, correcting for the bias using Altonji et al. (2005b) method predicts an even more negative effect of Catholic schooling on grade repetition than the effect found using our IV. Using a more informal approach, we estimate that if selection on unobservables were less than half as strong (approximately 40%) as that found on a limited set of observables, the effect of Catholic schooling would be explained away.[27] Overall, this sensitivity analysis confirms that the OLS estimates are driven by selection bias and that Catholic schooling increases the likelihood of grade repetition.

[26] Note that this is an extreme assumption because datasets are designed to answer particular questions and researchers do not choose their controls randomly. Therefore, selection on unobservables is likely to be less than selection on observables. However, for large datasets, such as the US Census, the actual selection on unobservables may be closer to the selection implied by the equal selection assumption than to the one that uses smaller longitudinal surveys containing a rich set of individual characteristics (e.g., NLSY79, NELS:88 etc.).

[27] Altonji et al. (2005b) show that if the bias in a probit is close to the bias in OLS, then

$$plim \quad \hat{\alpha} = \alpha + \frac{Cov(\tilde{P}, \epsilon)}{Var(\tilde{P})} = \alpha + \frac{Var(P)}{Var(\tilde{P})[E(\epsilon|P=1) - E(\epsilon|P=0)}$$

where $\tilde{P}$ is the residual from a regression of P on the set of observable controls X. Under the assumption that observable and unobservable determinants of student outcomes have the same relationship with Catholic schooling, $\frac{E(\epsilon|P=1)-E(\epsilon|P=0)}{Var(\epsilon)} = \frac{E(X'\gamma|P=1)-E(X'\gamma|P=0)}{Var(X'\gamma)}$. Therefore,

$$plim \quad \hat{\alpha} = \alpha + \frac{Cov(\tilde{P}, \epsilon)}{Var(\tilde{P})} = \alpha + \frac{E(X'\gamma|P=1) - E(X'\gamma|P=0)}{Var(X'\gamma)}$$

The ratio between the unconstrained estimate of α and the estimated selection bias can then be used to measure how strong the selection on unobserved characteristics should be relative to the selection on observables for explaining all of the effects of parochial schooling.

3.4.4 The Effects Across Socio-Demographic Groups

Previous studies found larger positive effects of Catholic schooling on minority students. In Table 3.6, we report the 2SLS estimates by race, ethnicity and poverty level. Column 1 replicates the estimate of column 4 in Table 3.3. In column 2, we restrict the sample to whites. The 2SLS coefficient is still not significantly different from zero, but the estimate is more precisely estimated. Focusing on non-Hispanic whites, the coefficient becomes significant and suggests that parochial schooling increases the likelihood of repeating a grade by 20%. The sign of the coefficient becomes negative when we look at minorities. While the large variance does not allow for making strong inferences, the direction of the effect appears to be consistent with previous studies on Catholic schooling and minorities. The coefficient is positive and significant when we analyze children hailing from families above the median poverty level (i.e., of higher socio-economic status), and the effect is less precisely estimated for children of families with lower socio-economic status.

3.4.5 Did the Shock Affect the Quality of Catholic Schools?

A potential threat to the validity of the exogeneity assumption is the fact that the shock to the supply of Catholic sisters may have had an impact not only on the supply of Catholic schools and tuition costs but also on the average quality of surviving Catholic schools. It is reasonable to assume that the sudden decline in the number of Catholic sisters also affected the quality of Catholic school personnel. The literature suggests that the higher dedication and vocational motivation of Catholic school teachers is one mechanism behind the positive effects of Catholic schooling (Neal, 1997). In addition to higher motivation, Kim (2011) shows that religious personnel were, on average, more educated and more experienced. The

Notre Dame Survey on American Catholic Schools of 1966 provides aggregate descriptives that confirm the relative higher experience, education and work satisfaction of religious teachers compared to lay teachers in Catholic schools. In particular, we know that 49% of Catholic sisters had a Masters degree compared to only 19% of lay teachers. Furthermore, sisters were often required to attend educational and training programs. Koedel (2008) shows that teacher quality and education have significant effects on graduation outcomes. If we believe that the higher education and motivation of sisters had a significant and positive impact on the student outcomes, we should expect our reduced-form coefficient to be upward-biased. We document the evidence of a negative association between the share of religious teachers and the likelihood of grade repetition in Catholic schools (see Table 3.7). Our results show that the ratio of religious teachers to lay teachers in Catholic schools (or the share of Catholic sisters among Catholic school teachers) is negatively associated with the likelihood of grade repetition among students attending Catholic schools (see column 1). In particular, we find that a one standard deviation in the sister-lay teacher ratio is associated with a 3% decline in grade repetition. This is equivalent to a 21% effect with respect to the average grade repetition rate among parochial school students (14.7%). The coefficient becomes non-significant when focusing on non-Hispanic whites (column 3) and is large and significant for minorities (column 4). The point-estimate implies that a one standard deviation increase in the sister-lay teacher ratio is associated with a 57% decrease in the likelihood of repeating a grade for minority students attending parochial schools. Similarly, the coefficient is non-significant when looking at students whose families are above the median poverty level (i.e., of higher socio-economic status, column 5) but negative and significant for students of lower socio-economic status (- 23%, column 6).

These results are in line with the idea that more qualified and motivated teachers may be more productive for disadvantaged students (Kim, 2011; Koedel, 2008). The results also help explain the positive results found by Neal (1997) when looking at the effect of Catholic schools on urban minorities. Exploring the effects of the Second Vatican Council on the quality of teachers in Catholic schools goes well beyond the main purpose of this paper and would require additional micro-level data on teachers and school characteristics (Kim, 2011). However, it is important to discuss how the effects of the Second Vatican Council on teacher quality may affect the validity of our identification strategy. Because we argued that the higher quality of Catholic sister teachers had a significant and negative impact on grade retention, we expect our reduced-form coefficient to be downward-biased. Therefore, because we find a null or positive effect on grade retention, we interpret our IV estimates as plausibly identifying a lower bound on the effects of Catholic schooling on grade retention.

Other Educational Outcomes

In Table 3.8, we investigate the reduced-form relationship between the average number of Catholic sisters and other measures of educational attainment. Unfortunately, the lack of information on the Catholic school attendance of former students prevents us from estimating the treatment effects of Catholic schooling. Similar to the approach used in Section 3.3, we compute the average number of nuns available to each individual living in a different diocese during his schooling years. In column 1, we consider the relation between the exposure to Catholic sisters and the likelihood of being enrolled in school at

the age of post-compulsory education, i.e., upon attaining the legal dropout age.[28] The coefficient is positive but highly insignificant. Column 2 considers the effect of dropping out of high school. We use the standard definition and consider individuals between 16 and 24 years of age who did not obtain high school diplomas and were not enrolled in school as dropouts. We restrict the sample to individuals who resided in the same MSA for the 5 years preceding the survey. The coefficient is only marginally significant and points to a positive relationship between the number of Catholic sisters available during a students schooling years and the likelihood of being a high school dropout. In column 3, we examine the high school graduation rates of individuals between 18 and 23 years of age. Similarly, in column 4, we look at the likelihood of having attended some college for individuals between 18 and 23 years of age. We do not find evidence of significant effects on any of these educational outcomes.[29] However, these estimates should be considered with caution because by looking at the outcomes of older cohorts, we substantially increase the selectivity in the sample and compromise the ability of controlling for parental background.

3.5 Conclusion

A large literature has investigated the relationship between Catholic schooling and student outcomes. Most of the previous studies have found positive effects, but the causality has long been questioned. This paper proposes a new identification strategy for assessing the effects of Catholic schooling on student outcomes. We exploit an exogenous shock to

[28] States differ in their compulsory schooling requirement. We follow Angrist and Krueger (1991) in defining the legal dropout age, which is a combination of compulsory schooling laws and school starting age.

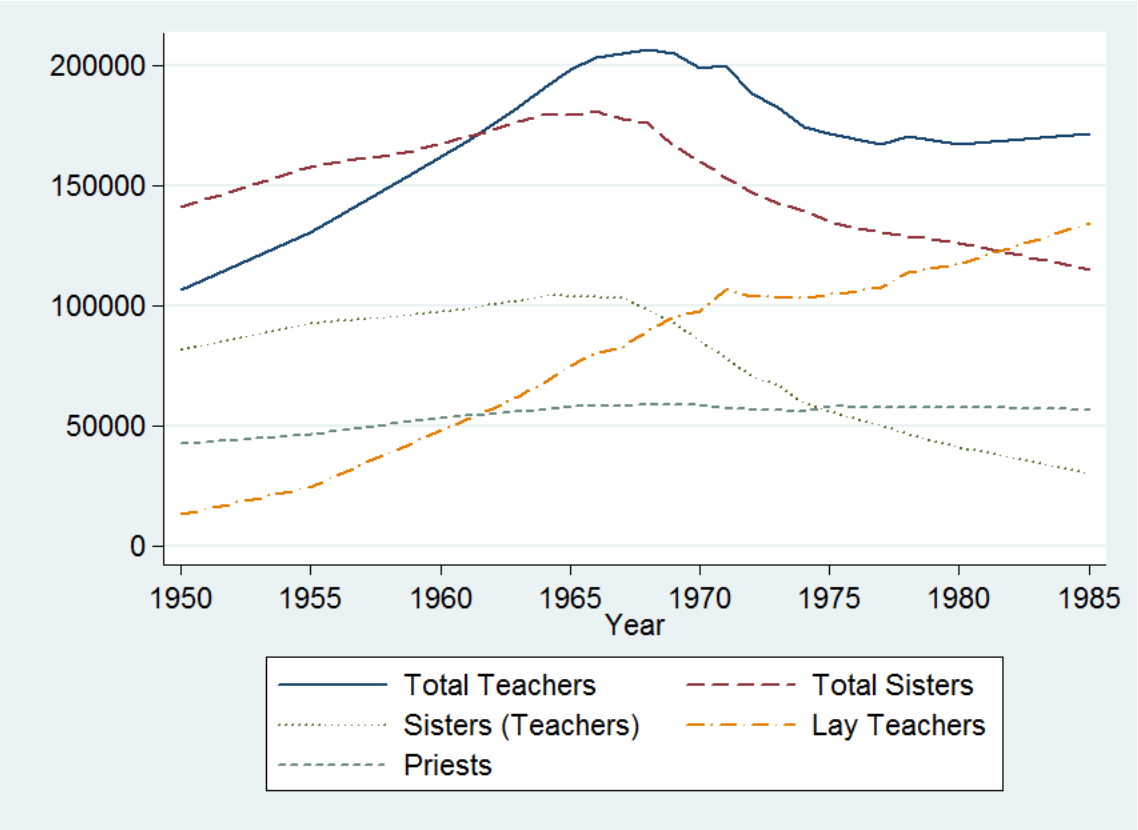
[29] Note that when further restricting the sample to individuals born in the same state in which they currently reside, the results do not change significantly. However, the coefficient on high school dropouts becomes insignificant.

the number of Catholic sisters and show that the positive correlation between Catholic schooling and student outcomes is explained entirely by selection bias.

We show that the unexpected shock to the supply of Catholic sisters, induced by the changes sparked by the Second Vatican Council, affected the number of Catholic schools and, in turn, the likelihood of children attending Catholic schools. Additionally, we present evidence that compared to previous instruments used in the literature, our instrumental strategy is less likely to violate the exclusion restriction. We confirm the previous findings of a positive correlation between Catholic schooling and educational outcomes. However, using our instrument to identify the causal effects of Catholic schooling on grade repetition, we find no evidence of positive effects and reject the OLS estimates. If anything, our estimates imply that Catholic schooling increases the likelihood of repeating a grade. These results are similar to those found by Elder and Jepsen (2013) using more recent data on primary schools. To verify the plausibility of our results, we use the techniques of Altonji et al. (2005b) and show that even a modest degree of selection on unobservable characteristics is sufficient to eliminate and reverse the sign of Catholic schooling. We find no evidence of positive effects when analyzing different measures of educational attainment using reduced-form relationships.

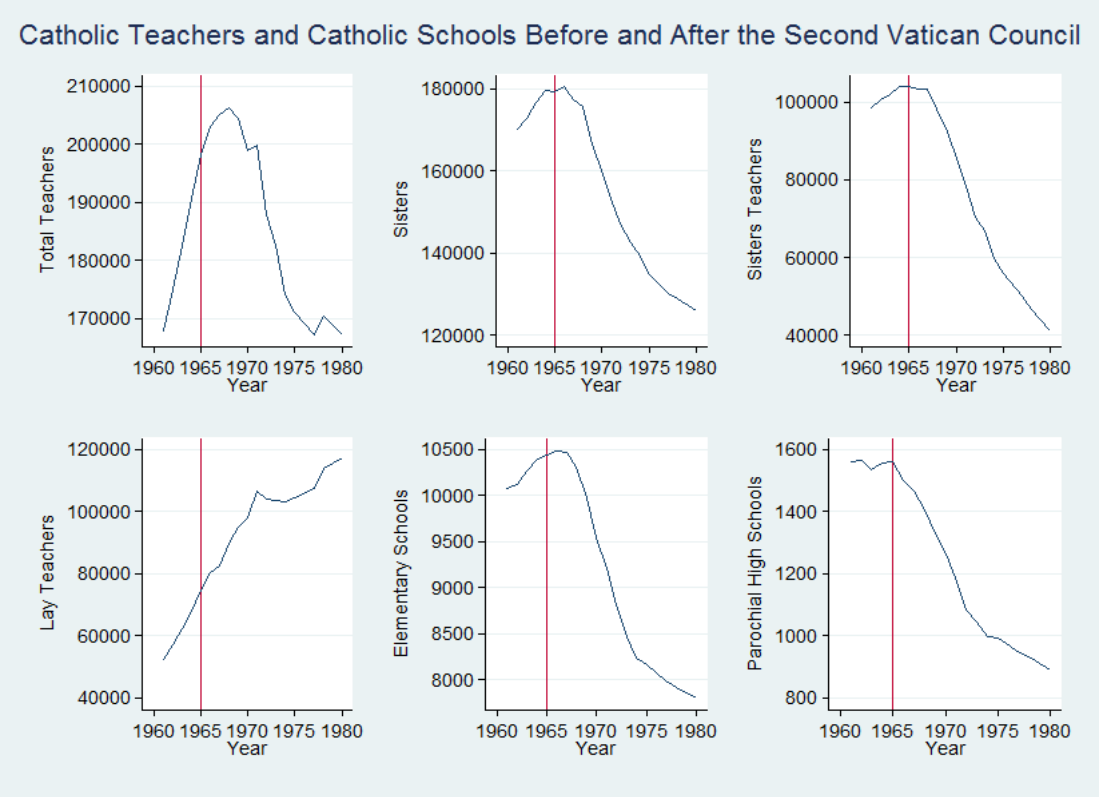
A natural extension of this study would be to adopt our identification strategy to analyze the effects of private school competition on educational attainment. Further research could also use this approach to reassess the effects of Catholic schooling on labor market outcomes and behaviors. Finally, along with parochial education, Catholic sisters were largely involved in health care (Sack, 2011). Future studies could analyze how the drastic decline of religious orders affected American hospitals.

Figure 3.1: Human Assets in the American Catholic Church, 1950-1985



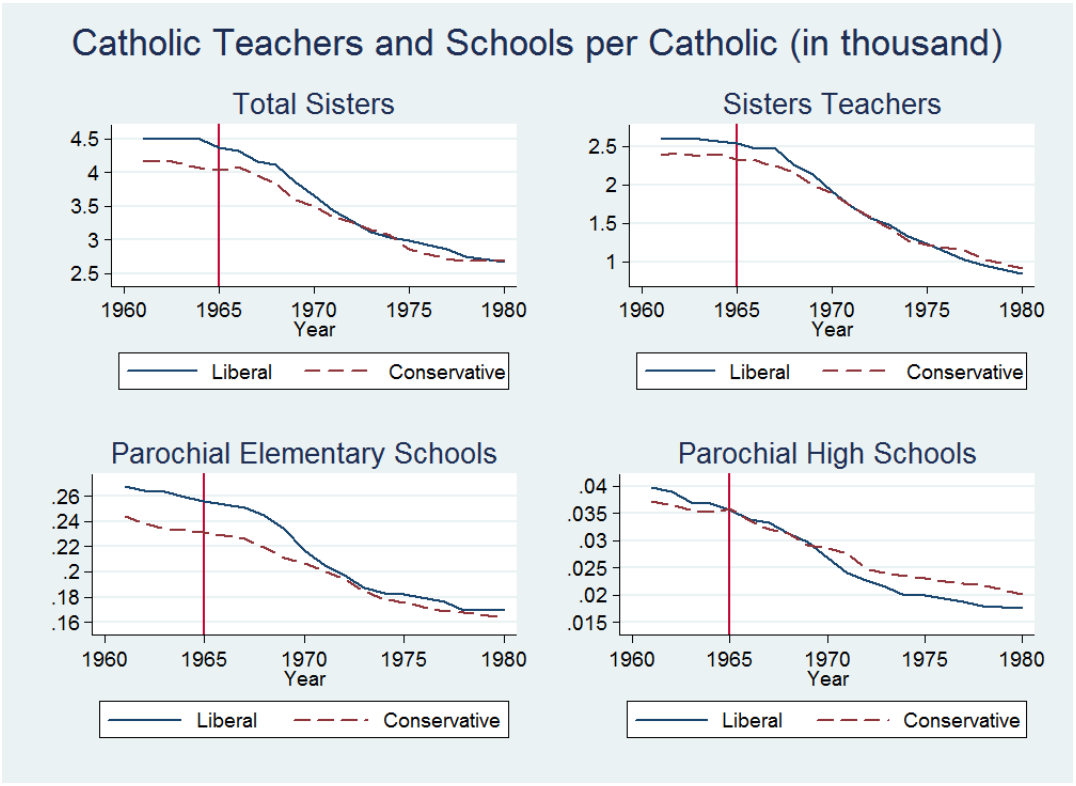
Notes - Number of Sisters, Priests, Teachers in Catholic Schools, Sister Teachers, Lay Teachers. Source: Official Catholic Directory 1950-1985.

Figure 3.2: The Decline of Catholic Sisters and Catholic Schools Across US



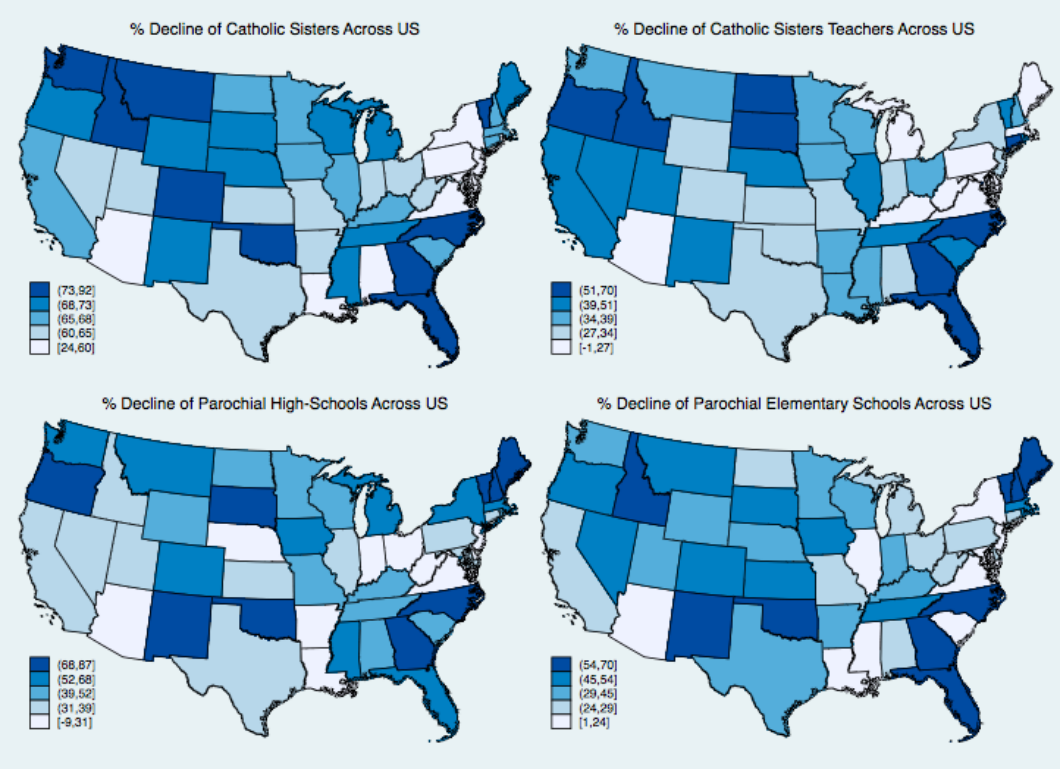
Notes - Source: Official Catholic Directory 1960-1980.

Figure 3.3: The Decline of Catholic Sisters and Catholic Schools Across Liberal and Conservative Dioceses



Notes - Source: Official Catholic Directory 1960-1980. Voting records of Bishops at Vatican II (collected by Melissa Wilde, 2007).

Figure 3.4: The Decline of Catholic Sisters Across US States (1966-1980)



Notes - Source: Official Catholic Directory 1966 and 1980. States are classified in 5 categories. The darker the blue the higher the decline in the number of Catholic sisters and parochial schools between 1966 and 1980.

Table 3.1: Heterogeneity in the Vatican II Shock across US dioceses

	(1) Sisters per 1,000 Catholics	(2) Sisters Teachers per 1,000 Catholics	(3) Sisters per 1,000 Catholics	(4) Sisters Teachers per 1,000 Catholics
Vatican II	-1.832***	-1.474***	-1.858***	-1.489***
	(0.066)	(0.042)	(0.066)	(0.042)
Vatican II * conservative diocese	0.218*	0.163**	0.192*	0.147**
	(0.114)	(0.073)	(0.114)	(0.073)
Vatican II * most conservative diocese			0.913***	0.540***
			(0.281)	(0.179)
Diocese fixed effect	YES	YES	YES	YES
Observations	2,307	2,307	2,307	2,307
R-squared	0.328	0.439	0.332	0.441

Notes - Source: Official Catholic Directory (1960-1980) and voting records of Bishops at Vatican II collected by Wilde (2007) from the Vatican Secret Archive (Archivio Segreto Vaticano). The sample is restricted to the 105 dioceses for which we have information on Bishop's vote at the Second Vatican Council.

Table 3.2: IVs and Individual Observable Characteristics (standardized coefficients)

	(1)	(2)	(3)	(4)	(5)
			Univariate regressions		
				(Cohen-Zada & Elder, 2009)	
Census Variables	1970-1980 Mean	1970-1980 S.d.	1970-1980 Sisters (in thousands)	1980 pcath1890/pcath1980	1970-1980 Enrolled in a parochial school
Grade repetition	0.18	0.38	-0.002	**0.017***	**-0.043*****
Enrolled in a parochial school	0.14	0.35	**0.063*****	**0.0101*****	**1.000*****
Male	0.51	0.50	0.002	0.003	**-0.014*****
Black	0.11	0.31	-0.001	**0.118****	**-0.060*****
Hispanic	0.10	0.29	-0.021	**0.102***	**-0.013****
Mother's education	2.18	0.94	**0.023*****	**-0.053***	**0.180*****
Father's education	2.38	1.11	**0.029*****	**-0.068****	**0.220*****
Log (family income)	9.40	0.64	**0.068*****	**-0.078****	**0.137*****

Notes - Data are drawn from the 1970 and 1980 US Census. The sample is restricted to children 7-15 years old. Column 3 includes MSA and cohort fixed effects. Column 4 includes state fixed effects. Standard errors were clustered at the MSA level in column 3 and at the county level in column 4.

Table 3.3: Sisters, Catholic Schooling and Grade Retention

	(1) First Stage	(2) OLS	(3) Reduced-Form	(4) IV
Dependent variable	Enrolled in a Parochial School	Grade Repetition	Grade Repetition	Grade Repetition
Sisters (in thousand)	0.023***		0.005	
	(0.006)		(0.004)	
Enrolled in a parochial school		-0.020***		0.255
		(0.003)		(0.167)
Observations	841,958	841,958	841,958	841,958
First-stage F (1, 121)	14.84			
Mean of dependent variable	0.139	0.176	0.176	0.176
s.d.	0.346	0.381	0.381	0.381

Notes - Data are drawn from the 1970 and 1980 US Census. The sample is restricted to children 7-15 years old. All estimates include controls for a set of child's characteristics (gender, race, Hispanic ethnicity, birth quarter, age dummies), family background (maternal and paternal age (quadratic), maternal and paternal education (4-groups), family income), MSA and cohort fixed effects, and a set of MSA time varying characteristics (female labor force participation, and teachers' education). Standard errors are clustered at the MSA level.

Table 3.4: Sisters, Catholic Schooling and Grade Retention, 4 Largest Dioceses, County-Level Variation

	(1) First Stage	(2) OLS	(3) Reduced-Form	(4) IV
Dependent variable	Enrolled in a Parochial School	Grade Repetition	Grade Repetition	Grade Repetition
Sisters (in thousand)- county level	0.067**		0.007	
	(0.027)		(0.004)	
Enrolled in a parochial school		-0.022***		0.107*
		(0.005)		(0.060)
Observations	117,376	117,376	117,376	117,376
First-stage F (1, 7)	7.17			
Mean of dependent variable	0.209	0.173	0.173	0.173
s.d.	0.406	0.378	0.378	0.378

Notes - Data are drawn from the 1970 and 1980 US Census. The sample is restricted to children 7-15 years old living in counties belonging to the 4 largest U.S. dioceses: Chicago, Detroit, New York, and Los Angeles. All estimates include controls for a set of child's characteristics (gender, race, Hispanic ethnicity, birth quarter, age dummies), family background (maternal and paternal age (quadratic), maternal and paternal education (4-groups), family income), county and cohort fixed effects, and a set of county time varying characteristics (female labor force participation, teachers'education and Catholic population). Standard errors are clustered at the MSA level.

Table 3.5: Effects of Catholic Schooling on Grade Retention Accounting for Selection on Observables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Constrained							Equal Selection
ρ	0	-0.05	-0.1	-0.2	-0.3	-0.4	-0.5	-0.727 (0.000)
Enrolled in parochial school	-0.023 (0.001)	0.006 (0.001)	0.022 (0.001)	0.070 (0.001)	0.119 (0.001)	0.171 (0.001)	0.224 (0.001)	0.358 (0.001)

Notes - Data are drawn from the 1970 and 1980 US Census. The sample is restricted to children 7-15 years old. These are estimates from a bivariate probit models imposing the various restrictions. All estimates include child's characteristics (gender, race, Hispanic ethnicity, birth quarter, age dummies), family background (maternal and paternal age (quadratic), maternal and paternal education (4-groups), family income). The outcome variable is grade repetition.

Table 3.6: Catholic Schooling and Grade Retention, by Socio-Demographic Groups

	(1) All	(2) Whites	(3) Non-Hispanic Whites	(4) Minorities	(5) Below median poverty level	(6) Above median poverty level
Enrolled in a parochial school	0.253	0.170	0.213**	-0.0509	0.304**	0.255
	(0.167)	(0.108)	(0.093)	(0.321)	(0.143)	(0.316)
Observations	841,958	751,302	671,872	170,086	414,058	427,900
Mean of dependent Variable	0.176	0.173	0.163	0.227	0.138	0.213
s.d.	0.381	0.378	0.369	0.419	0.345	0.409

Notes - Data are drawn from the 1970 and 1980 US Census. The sample is restricted to children 7-15 years old. All estimates include controls for a set of child's characteristics (gender, race, Hispanic ethnicity, birth quarter, age dummies), family background (maternal and paternal age (quadratic), maternal and paternal education (4-groups), family income), MSA and cohort fixed effects, and a set of MSA time varying characteristics (female labor force participation, and teachers' education). Standard errors are clustered at the MSA level.

Table 3.7: Sisters-Lay Teachers Ratio and Grade Retention in Catholic Schools

	(1) All	(2) Whites	(3) Non-Hispanic Whites	(4) Minorities	(5) Below median poverty level	(6) Above median poverty level
Sisters-Lay Teachers Ratio	-0.030**	-0.027*	-0.022	-0.111***	-0.020	-0.041***
	(0.015)	(0.015)	(0.015)	(0.027)	(0.018)	(0.015)
Observations	117,148	110,578	100,803	16,345	64,217	52,931
Mean of dependent variable	0.147	0.144	0.137	0.192	0.125	0.168
s.d.	0.345	0.344	0.338	0.384	0.328	0.364

Notes - Data are drawn from the 1970 and 1980 US Census. The sample is restricted to children 7-15 years old enrolled in parochial schools. All estimates include controls for a set of child's characteristics (gender, race, Hispanic ethnicity, birth quarter, age dummies), family background (maternal and paternal age (quadratic), maternal and paternal education (4-groups), family income), MSA and cohort fixed effects, and a set of MSA time varying characteristics (female labor force participation, teachers' education, and Catholic population). Minorities include blacks and Hispanics. Standard errors are clustered at the MSA level.

Table 3.8: Other Outcomes - Reduced Form Analysis

Dependent Variable	(1) Dropout at post-compulsory age	(2) HS dropout (age 16-24)	(3) HS graduation (age 18-23)	(4) Some College (age 18-23)
Sisters (in thousands)	0.008	0.007*	0.001	-0.011
	(0.006)	(0.004)	(0.007)	(0.011)
Observations	100, 161	340,612	253,128	253,128
Mean of dependent Variable	0.105	0.150	0.754	0.323
s.d.	0.306	0.357	0.431	0.468

Notes - Data are drawn from the 1970 and 1980 US Census. All estimates include controls for a set of individual's characteristics (gender, race, Hispanic ethnicity, birth quarter, age dummies), MSA and cohort fixed effects, and a set of MSA time varying characteristics (female labor force participation, teachers' education and Catholic population). Columns 2-4 further restrict the sample to individuals who were residing in the same metropolitan area 5 years before the Census. Standard errors are clustered at the MSA level.

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