Investment in Schooling and the Marriage Market*

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Abstract

We present a model in which investment in schooling generates two kinds of returns: the labor-market return, resulting from higher wages and a marriage-market return, defined as the impact of schooling on the marital surplus share one can extract. Men and women may have different incentives to invest in schooling because of different market wages or household roles. This asymmetry can yield a mixed equilibrium with some educated individuals marrying uneducated spouses. When the labor-market returns to schooling rises, home production demands less time and the traditional spousal labor division norms weaken, more women may invest in schooling than men.

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1 Introduction

The purpose of this paper is to provide a simple equilibrium framework for the joint determination of pre-marital schooling and marriage patterns of men and women. Couples sort according to education and, therefore, changes in the aggregate supply of educated individuals affects who marries whom and the division of the gains from marriage. Unlike other attributes such as race and ethnic background, schooling is an acquired trait that is subject to choice. Acquiring education yields two different returns: First, a higher earning capacity and better job opportunities in the labor market. Second, an improvement in the intra-marital share of the surplus one can extract in the marriage market. Educational attainment influences intra-marital shares by raising the prospects of marriage with an educated spouse and thus raising household income upon marriage, and by affecting the competitive strength outside marriage and the spousal roles within marriage.

The gains from schooling within marriage strongly depend on the decisions of others to acquire schooling. However, since much of schooling happens before marriage, partners cannot coordinate their investments. Rather, men and women make their choices separately, based on the anticipation of marrying a "suitable" spouse with whom schooling investments are expected to generate higher returns. Therefore, an equilibrium framework is required to discuss the interaction between marriage and schooling.

The basic ingredients of our model are as follows. We consider a frictionless marriage market in which, conditional on the predetermined spousal schooling levels, assignments are stable. That is, there are no men or women (married or single) who wish to form a new union and there are no men or women who are married but wish to be single. We then assume transferable utility between the spouses to characterize the stable assignments. We further assume that men and women can be divided into two schooling classes (high and low) and the interactions between married spouses depend only on their classes. In particular, although men and women have idiosyncratic preferences for marriage and investment in schooling, they all have the same ranking over spouses of the opposite sex which depends only on their schooling. Thus, every educated man (woman) and every uneducated man (woman) has a perfect substitute. The absence of rents allows us to pin down the shares of the marital surplus of men and women in each schooling class based on competition alone, without resorting to bargaining. These shares, together with the known returns as singles, are sufficient to determine the investments in schooling of men and women.

We apply our framework to analyze why women may overtake men in schooling despite their lower market wage rate and higher amount of housework compared with men. Our explanation relies on three phenomena. One is the higher *labor-market return* to schooling for women. The essence of the argument is that education can serve as a means to escape discrimination. Therefore, although women today still receive lower wages and spend more time in the household than men, they may acquire more schooling than men because discrimination is lower at higher levels of education. While the higher labor-market return may not be a new phenomenon, it was, in the past, washed out by the lower *marriage-market return* that women received because those educated women who chose to marry mainly worked at home. With the passage of time, the technology of home production improved, requiring women to spend less time at home. In addition, the traditional norms that required women to spend time at home, irrespective of their schooling attainments have weakened. These changes allowed married women to work more in the market, which raised their return from schooling within marriage. Third, these evolutions, beyond their direct impact on productivity at home and on the markets, have deeply affected the market for marriage, modifying both the marriage patterns and the division of surplus between spouses. Taking all these together, the total rate of return from education, including the labor-market and the marriage-market returns, may have risen more for women and may now exceed that of men.

We show that the equilibrium in the marriage market can then shift from one with excess supply of educated men (and some of them marrying down to uneducated women) to an equilibrium with excess supply of educated women (and some of them marrying down to uneducated men). Associated with this reversal, we have changes in the marital surplus and its division. First, as men and women become more educated, the marital surplus rises and, because of the complementarity in the schooling of married spouses, educated men benefit more than uneducated men in terms of *total* marital surplus. Moreover, with educated men being in short supply, men enjoy an increase in their return from schooling within marriage in the new equilibrium. Second, *some* uneducated men marry educated women and directly benefit from their wives' higher wages and increased labor-market participation. In equilibrium, this implies that the marital surplus received by uneducated men in *all* marriages rises. Conversely, uneducated women are much less likely to marry educated men, which in our frictionless model means that they exclusively marry uneducated men. As a consequence, they may suffer a reduction in their marital surplus, which boosts marriage-market returns to female education. In this manner, marriage market considerations can help to propagate the divergent patterns of educational attainments of both women and men. All in all, we argue that the marriage-market returns to education typically increase much more for women than for men, principally because of the asymmetric effects of the improvements in home production technology and the changes in norms governing the division of labor.

Of course, there are other possible reasons for why women may invest in schooling more than men. One reason is that there are more women than men in the marriage market at the relatively young ages at which schooling is chosen, because women marry younger. Iyigun and Walsh (2007) have shown, using a similar model to the one discussed here, that in such a case women will be induced to invest more than men in competition for the scarce males. Another reason is that divorce is more harmful to women, because men are more likely to initiate divorce when the quality of match is revealed to be poor. This asymmetry is due to the higher income of men and the usual custody arrangements (see Chiappori and Weiss, 2007). In such a case, women may use schooling as an insurance device that mitigates their costs from unwanted divorce. Gosling (2003) argues that wages are determined by several factors and women who typically lack "brawn" have stronger incentive to invest in "brains". Charles and Luoh (2003) bring evidence that among men the variability in earnings rises with schooling more than among women suggesting that investment in schooling is less "risky" for women. Finally, Goldin et al. (2006) argue that the costs of college education are lower for women because they accumulate more education in high school. Our contribution is to take one plausible explanation and use an economic model to explore its implications for several jointly determined variables of interest; schooling choices of men and women, the associated marriage patterns and the division of the gains from marriage.

Our work relates to several burgeoning strands in the literature: first there is theoretical work on coordination in large markets and the connections between premarital investment and intra-household allocations. (Baker and Jacobsen, 2007, Cole et al, 2001, Hadfield, 1999, Iyigun and Walsh, 2007, Lommerud and Vagstad, 2000 and Peters and Siow, 2002); second we have empirical work on the relationship between sex ratios and intra-household resource allocations (Angrist, 2002, Chiappori, Fortin and LaCroix, 2002, Grossbard-Shechtman, 1995, and Seitz, 2005); and finally there is a strand that uses stable matching to characterize partnership/marriage formation (Del Boca and Flinn, 2006, Ariely, Hitsch, and Hortacsu, 2006, Choo and Siow, 2006, and Choo et al., 2007).

2 The Basic Model

We begin with a benchmark model in which men and women are completely symmetric in their preferences and opportunities. However, by investing in schooling, agents can influence their marriage prospects and labor market opportunities. Competition over mates determines the assignment (i.e., who marries whom) and the shares in the marital surplus of men and women with different levels of schooling, depending on the aggregate number of women and men who acquire schooling. In turn, these shares together with the known market wages guide the individual decisions to invest in schooling and to marry. We investigate the rational-expectations equilibrium that arises under such circumstances.

2.1 Definitions

When man i and woman j form a union, they generate some aggregate *material output* ζ_{ij} that they can divide between them and the utility of each partner is linear in the share he\she receives (transferable utility). Man i alone can produce ζ_{i0} and woman j alone can produce ζ_{0j}. The *material surplus* of the marriage is defined as

$$z_{ij} = \zeta_{ij} - \zeta_{i0} - \zeta_{0j}. \tag{1}$$

In addition, there are emotional gains from marriage and the total *marital surplus* generated by a marriage of man i and woman j is

$$s_{ij} = z_{ij} + \theta_i + \theta_j, \tag{2}$$

where θ_i and θ_j represent the non-economic gains of man i and woman j from their marriage.

2.2 Assumptions

There are two equally large populations of men and women to be matched. Individuals live for two periods. Each person can choose whether or not to acquire schooling and whether and whom to marry. Investment takes place in the first period of life and marriage in the second period. Investment in schooling is lumpy and takes one period so that a person who invests in schooling works only in the second period, while a person who does not invest works in both periods. To simplify, we assume no credit markets.[1] All individuals with the same schooling and of the same gender earn the same wage rate but wages may differ by gender. We denote the wage of educated men by w_2^m and the wage of uneducated men by w_1^m, where $w_2^m > w_1^m$. The wages of educated women and uneducated women are respectively denoted by w_2^w and w_1^w, where $w_2^w > w_1^w$. Market wages are taken as exogenous and we do not attempt to analyze here the feedbacks from the marriage market and investments in schooling to

[1] Allowing borrowing and lending raises issues such as whether or not one can borrow based on the income of the future spouse and enter marriage in debt (see Browning et al., forthcoming, ch. 7).

the labor market.[2] We shall discuss, however, different wage structures.

We denote a particular man by i and a particular woman by j. We represent the schooling level (class) of man i by $I(i)$ where $I(i) = 1$ if i is uneducated and $I(i) = 2$ if he is educated. Similarly, we denote the class of woman j by $J(j)$ where $J(j) = 1$ if j is uneducated and $J(j) = 2$ if she is educated. An important simplifying assumption is that the material surplus generated by a marriage of man i and woman j depends only on the class to which they belong. That is,

$$s_{ij} = z_{I(i)J(j)} + \theta_i + \theta_j. \tag{3}$$

We assume that the schooling levels of married partners complement each other so that

$$z_{11} + z_{22} > z_{12} + z_{21}. \tag{4}$$

Except for special cases associated with the presence of children, we assume that the surplus rises with the schooling of both partners.[3] When men and women are viewed symmetrically, we also have $z_{12} = z_{21}$.

The per-period material utilities of man i and woman j as singles also depend on their class, that is $\zeta_{i0} = \zeta_{I(i)0}$ and $\zeta_{0j} = \zeta_{0J(j)}$ and are assumed to increase in $I(i)$ and $J(j)$. Thus, a more educated person has a higher utility as a single. Men and women who acquire no schooling and never marry have life time utilities of $2\zeta_{10}$ and $2\zeta_{01}$, respectively. A person that invests in schooling must give up the first-period utility and, if he\she remains single, the life time utilities are ζ_{20} for men and ζ_{02}

[2] Theoretically, wages are completely pinned down by linear, constant returns to scale, technology. We thus ignore the impact of changes in supply on the wages associated with schooling. In the context of a period dominated by increasing demand for skills, this omission is not as serious as it would otherwise be (see Katz and Autor, 1999).

[3] Complementarity between spousal traits is not necessary for our main conclusions. The key insight is that a short supply in the marriage markets raises the intra-marital returns. A case in which spousal traits are substitutes is analyzed in Iyigun and Walsh (2007).

for women. Thus, the (absolute) return from schooling for never married men and women are $R^m = \zeta_{20} - 2\zeta_{10}$ and $R^w = \zeta_{02} - 2\zeta_{01}$, respectively. These returns depend only on the wages associated with each level of schooling and can be different for men and women if their wages differ. We shall refer to these returns as the *labor-market* returns to schooling. Those who marry have an additional return from schooling investment in the form of an increased share in the material surplus, which can also be different for men and women and we shall refer these additional returns as the *marriage-market returns* to schooling. In addition to the returns in the labor market or marriage, investment in schooling is associated with idiosyncratic costs (benefits) denoted by μ_i for men and μ_j for women.

The idiosyncratic preference parameters are assumed to be independent of each other and across individuals. We denote the distributions of θ by $F(\theta)$ and assume that this distribution is symmetric around its zero mean. We let $G(\mu)$ denote the distribution of μ.

2.3 The Marriage Market

Any *stable* assignment of men to women must maximize the *aggregate* marital surplus (or output) over all possible assignments (Shapley and Shubik, 1972). The maximization of the aggregate surplus is equivalent to the maximization of aggregate output because the utilities as singles are independent of the assignments. The dual of this linear programming problem posits the existence of non-negative shadow prices associated with the constraints of the primal that each person can be either single or married to one spouse. We denote the shadow price of woman j by u_j and the shadow price of man i by v_i. The complementarity slackness conditions require that

$$z_{I(i)J(j)} + \theta_i + \theta_j \leq v_i + u_j, \tag{5}$$

with equality if i and j are married and inequality otherwise.

The complementarity slackness conditions are equivalent to

$$\begin{aligned} v_i &= Max\{\underset{j}{Max}[z_{I(i)J(j)} + \theta_i + \theta_j - u_j], 0\} \\ u_j &= Max\{\underset{i}{Max}[z_{I(i)J(j)} + \theta_i + \theta_j - v_i], 0\}, \end{aligned} \tag{6}$$

which means that the assignment problem can be *decentralized*. That is, given the shadow prices u_j and v_i, each agent marries a spouse that yields him\her the highest share in the marital surplus. We can now define $\bar{u}_j = u_j + \zeta_{0j}$ and $\bar{v}_i = v_i + \zeta_{i0}$ as the *reservation utility* levels that woman j and man i require to participate in *any marriage*. In equilibrium, a stable assignment is attained and each married person receives his\her reservation utility, while each single man receives ζ_{i0} and each single woman receives ζ_{0j}.

Our specification imposes a restrictive but convenient structure in which the interactions between agents depend on their group affiliation only, i.e., their levels of schooling. Assuming that, in equilibrium, at least one person in each class marries, the endogenously-determined shadow prices of man i in $I(i)$ and married j in $J(j)$ can be written in the form,

$$v_i = Max(V_{I(i)} + \theta_i, 0) \quad \text{and} \quad u_j = Max(U_{J(j)} + \theta_j, 0) \ , \tag{7}$$

where

$$V_I = \underset{J}{Max}[z_{IJ} - U_J] \quad \text{and} \quad U_J = \underset{I}{Max}[z_{IJ} - V_I] \tag{8}$$

are the *shares* that the partners receive from the *material surplus* of the marriage (not accounting for the idiosyncratic effects θ_i and θ_j). All agents of a given type receive the *same* share of the material surplus z_{IJ} no matter whom they marry, because all the agents on the other side rank them in the same manner. Any man (woman) of a given type who asks for a higher share than the "going rate" cannot obtain it because he (she) can be replaced by an equivalent alternative. Clearly no man or woman marries if the marital surplus, $V_{I(i)} + \theta_i$ or $U_{J(i)} + \theta_i$ is negative. It is possible, however, that the material surplus shares V_I or U_J are negative. In that case, the material utility that agent $i \in I$ or $j \in I$ receives when married is lower than what he\she would get as single. Such agents may still marry if the non-monetary gain that they derive from marriage, θ_i or θ_j, compensates for their material loss.

Although we assume equal numbers of men and women in total, it is possible that the equilibrium numbers of educated men and women will differ. We shall assume throughout that there are some uneducated men who marry uneducated women and some educated men who marry educated women. This means that the equilibrium shares must satisfy

$$U_2 + V_2 = z_{22}, \tag{9}$$

$$U_1 + V_1 = z_{11}. \tag{10}$$

We can then classify the possible matching patterns as follows: Under *strict* positive assortative mating, educated men marry only educated women and uneducated men marry only uneducated women. Then,

$$U_1 + V_2 \geq z_{21}, \tag{11}$$

$$U_2 + V_1 \geq z_{12}. \tag{12}$$

If there are more educated men than women among the married, some educated men will marry uneducated women and condition (11) will also hold as an equality. If there are more educated women than men among the married, equation (12) will hold as an equality. It is impossible that all four conditions will hold as equalities because this would imply

$$z_{22} + z_{11} = z_{12} + z_{21}, \tag{13}$$

which violates assumption (4) that the education levels of the spouses are complements. Thus, either educated men marry uneducated women or educated women marry uneducated men, but not both.

When types mix and there are more educated men than educated women among the married, conditions (9) through (11) imply

$$\begin{aligned} U_2 - U_1 &= z_{22} - z_{21}, \\ V_2 - V_1 &= z_{21} - z_{11}. \end{aligned} \tag{14}$$

If there are more educated women than men among the married, then conditions (9), (10) and (12) imply

$$\begin{aligned} V_2 - V_1 &= z_{22} - z_{12}, \\ U_2 - U_1 &= z_{12} - z_{11}. \end{aligned} \tag{15}$$

One may interpret the differences $U_2 - U_1$ and $V_2 - V_1$ as the *returns to schooling in marriage* for women and men, respectively. The quantity $z_{22} - z_{21}$, which reflects the contribution of an educated woman to the material surplus of a marriage with an educated man, provides an *upper bound* on the return that a woman can obtain through marriage, while her contribution to a marriage with an uneducated man, $z_{12} - z_{11}$, provides a *lower bound*. Analogous bounds apply to men. When types mix in the marriage market equilibrium, we see that the side that is in short supply receives the marginal contribution to a marriage with an educated spouse, while the side in excess supply receives the marginal contribution to a marriage with an uneducated spouse.

2.4 Investment Decisions

We assume rational expectations so that, in equilibrium, individuals know V_I and U_J, which are sufficient statistics for investment decisions. Given these shares and knowledge of their own idiosyncratic preferences for marriage, θ, and costs of schooling, μ, agents know for sure whether or not they will marry in the second period, conditional on their choice of schooling in the first period.

Man i chooses to invest in schooling if

$$\zeta_{20} - \mu_i + Max(V_2 + \theta_i,\ 0) > 2\zeta_{10} + Max(V_1 + \theta_i, 0). \tag{16}$$

Similarly, woman j chooses to invest in schooling if

$$\zeta_{02} - \mu_j + Max(U_2 + \theta_j, 0) > 2\zeta_{01} + Max(U_1 + \theta_j, 0). \tag{17}$$

Figure 1 describes the choices made by different men. Men for whom $\theta < -V_2$ do not marry and they invest in schooling if and only if $\mu < R^m \equiv \zeta_{20} - 2\zeta_{10}$. Men for whom $\theta > -V_1$ always marry and they invest in schooling if and only if $\mu < R^m + V_2 - V_1$. Finally, men for whom $-V_2 < \theta < -V_1$ marry if they acquire education and do not marry if they do not invest in schooling. These individuals acquire education if $\mu < R^m + V_2 + \theta$. In this range, there are two motives for schooling: to raise future earnings capacity and to enhance marriage. We assume that the variabilities in θ and μ are large enough to ensure that *all* these regions are non-empty in equilibrium. In particular, we assume that, irrespective of marital status, there are some men and women who prefer not to invest in schooling and some men and women who prefer to invest in schooling. That is, the upper bound of the support of the μ distribution is such that $\mu_{\max} > \max[R^m + z_{22} - z_{12},\ R^w + z_{22} - z_{21}]$ while the lower bound satisfies $\mu_{\min} < \min[R^m,\ R^w]$.

We shall also assume that $\theta_{\min} < -z_{22}$ so that, irrespective of the education decision, there are some individuals who wish not to marry. Note, finally, that because the support of $F(.)$ extends into the positive range, there are always some men and women who marry.

Inspecting Figure 1, we see that the proportion of men who invest in schooling is

$$G(R^m)F(-V_2) + [1 - F(-V_1)]G(R^m + V_2 - V_1) + \int_{-V_2}^{-V_1} G(R^m + V_2 + \theta)f(\theta)d\theta, \quad (18)$$

the proportion of men who marry is

$$[1 - F(-V_1)] + \int_{-V_2}^{-V_1} G(R^m + V_2 + \theta)\, f(\theta)\, d\theta, \quad (19)$$

and the proportion of men who invest and marry is

$$[1 - F(-V_1)]G(R^m + V_2 - V_1) + \int_{-V_2}^{-V_1} G(R^m + V_2 + \theta)f(\theta)d\theta. \quad (20)$$

In equation (18), the first term represents the proportion of men who don't marry and get educated; the second term denotes the proportion of men who do marry and get educated; the final term is equal to those men who get married *because* they are educated. Similarly, in equation (19), we have the proportion of men who marry regardless of their educational status in the first term and those who marry due to their educational attainment in the second term. By definition, equation (20) comprises of the final two terms of equation (18).

The higher are the returns to schooling in the labor market, R^m, and in marriage, $V_2 - V_1$, the higher is the proportion of men who acquire schooling. A common increase in the levels V_2 and V_1 also raises investment because it makes marriage more attractive and schooling obtains an *extra* return within marriage. For the same reason, an increase in the market return R^m raises the proportion of men that marry. Analogous expressions hold for women.

2.5 Equilibrium

In the marriage market equilibrium, the numbers of men and women who wish to marry must be the same. Using equation (19) and applying symmetry of $F(\theta)$, we can write this condition as

$$F(V_1) + \int_{V_1}^{V_2} G(R^m + V_2 - \theta) f(\theta) d\theta = F(U_1) + \int_{U_1}^{U_2} G(R^w + U_2 - \theta) f(\theta) d\theta, \qquad (21)$$

where the LHS of (21) represents the proportion of men who marry and the RHS denotes that of women who marry (recall that we assume equal number of men and women).

One can show that a unique equilibrium exists (the proof of existence and uniqueness is in our online Appendix). And depending on the parameters, it can be one of the three following types:

1. **Strictly positive assortative mating:** Educated men marry only educated women and uneducated men marry only uneducated women. Given that we impose condition (21), the number of educated (uneducated) men who marry must equal the number of educated (uneducated) women who marry. Using condition (20) and symmetry of $F(\theta)$, an equal number of uneducated men and uneducated women marry when

$$F(V_1)\left[1 - G(R^m + V_2 - V_1)\right] = F(U_1)\left[1 - G(R^w + U_2 - U_1)\right], \qquad (22)$$

which in turn implies that an equal number of educated men and educated women marry. The equilibrium, in this case, satisfies (22) in addition to (9), (10) and (21).

The other two cases involve some mixing of types. In mixed equilibria, equation (22) is replaced by an inequality and the shares are determined by the boundary conditions on the returns to schooling within marriage for either men or women, whichever is applicable.

Specifically:

2. **Some educated men marry uneducated women.** Here, there must be fewer uneducated men than uneducated women among the married

$$F(V_1)G(-R^m + V_1 - V_2) < F(U_1)G(-R^w + U_1 - U_2) \tag{22a}$$

and women receive their maximal return from schooling in marriage while men receive their minimal return. This equilibrium satisfies (14) in addition to (9), (10) and (21).

3. **Some educated women marry uneducated men.** Now we have

$$F(V_1)G(-R^m + V_1 - V_2) > F(U_1)G(-R^w + U_1 - U_2) \tag{22b}$$

and men receive their maximal return from schooling in marriage, while women receive their minimal return. This equilibrium satisfies (15) in addition to (9), (10), and (21).

The two first cases are described in Figures 2 and 3, where we depict the equilibrium conditions in terms of V_1 and V_2 after we eliminate U_1 and U_2 using (9) and

(10). The two positively-sloped and parallel lines in these figures describe the boundaries on the returns to schooling of men within marriage. The negatively-sloped line describes the combinations of V_1 and V_2 that maintain equality in the numbers of men and women who wish to marry. The positively-sloped steeper line describes the combinations of V_1 and V_2 that maintain equality in the numbers of men and women that acquire no schooling and marry. The slopes of these lines are determined by the following considerations: An increase in V_1 (and a reduction in U_1), keeping V_2 and U_2 constant, induces more men and fewer women to prefer marriage. An increase in V_2 holding V_1 has a similar effect. Thus, V_1 and V_2 are substitutes in terms of their impact on the incentives of men to marry and U_1 and U_2 are substitutes in terms of their impact on the incentives of women to marry. Therefore, equality in the number of men and women who wish to marry can be maintained only if V_2 declines when V_1 rises. At the same time, an increase in V_1 (and a reduction in U_1), keeping V_2 and U_2 constant, increases the number of men that would not invest and marry and reduces the number of women who wish to acquire no schooling and marry. Hence, equality in the numbers of uneducated men and women who wish to marry can be maintained only if V_2 rises when V_1 rises so that the rates of return to education within marriage are restored. Derivation of these properties is provided in the online Appendix.

As long as the model is completely symmetric, that is $R^m = R^w$ and $z_{12} = z_{21}$, the equilibrium is characterized by equal sharing: $V_2 = U_2 = z_{22}/2$ and $U_1 = V_1 = z_{11}/2$. With these shares, men and women have identical investment incentives. Hence, the number of educated (uneducated) men equals the number of educated (uneducated) women, both among the singles and the married. Such a solution is described by point e in Figure 2, where the lines satisfying conditions (21) and (22) intersect. There is a unique symmetric equilibrium. However, with asymmetry, when either

$R^m \neq R^w$ or $z_{12} \neq z_{21}$, there may be a mixed equilibrium where the line representing condition (21) intersects either the lower or upper bound on $V_2 - V_1$ so that condition (22) holds as an inequality. Such a case is illustrated by the point $e\prime$ in Figure 3. In this equilibrium, educated men obtain the lower bound on their return to education within marriage, $z_{21} - z_{11}$. The equilibrium point $e\prime$ is on the lower bound and above the steeper positively-sloped line satisfying condition (22), indicating excess supply of educated men.

We do not exclude the possibility of negative *equilibrium* values for some V_I or U_J. This would happen if the marginal person in a class is willing to give up in marriage some of the material output that he\she has as single, provided that the non-monetary benefit from marriage is sufficiently large. Then, all men (women) in that class are also willing to do so and the common factors, V_I or U_J may become negative. However, stability implies that the returns to schooling in marriage, $V_2 - V_1$ and $U_2 - U_1$ are positive in equilibrium, provided that the marital surplus rises with the education of both spouses.

3 Gender Differences in the Incentive to Invest

In this section, we first review some relevant empirical observations on marriage and spousal labor supply patterns as well as schooling by gender. Then, we utilize the model above to analyze how these empirical observations can come about and explore their implications for resource allocations and spousal matching.

3.1 Background

One of the salient trends in recent decades is the increased investment in education by women and the closing of the gap in schooling between men and women. In several developed countries, women now have more schooling than men.[4]

It is well documented that the market return to schooling has risen, especially in the second half of the 20th century. Thus, it is not surprising that women's demand for education has risen. What is puzzling, however, is the differential response of men and women to the changes in the returns to schooling. Women still receive lower wages in the labor market and spend more time at home than men, although these gaps have narrowed over time. Hence, one could think that women should invest in schooling less than men because education appears to be less useful for women both at home and in the market. In fact, while women considerably increased their investment in education in the last four decades, men hardly responded to the higher returns to schooling since the 1970s (see Goldin et al.,2006). This despite the fact that their market return from schooling appears to have increased at least as much as that for women since the late-1970s.

Figure 4 describes the time trends in levels of school completion for men and women, aged 30 to 40, in the United States. As seen, the proportions of women with some college education, college completion and advanced degrees (M.A., Ph.D.) have increased much faster than the corresponding proportions for men. By 2003, women had overtaken men in all of these three categories.

As seen in Figure 5, couples sort positively according to schooling and for about 50 percent of the married couples, the husband and wife have the same level of schooling (when broadly classified into 5 groups). However, changes in the aggregate number of educated men and women had a marked influence on who marries whom; 30 percent of the couples in the earlier cohorts had husbands who were more educated, whereas

[4] Goldin et al. (2006) show that, starting with the 1970 birth cohort, women have attained *higher* college graduation rates than men in the United States. They find similar reversals in 15 OECD countries.

30 percent of the couples in recent cohorts had wives with higher levels of educational attainment.[5]

Figure 6 brings evidence on work patterns *within couples* for husbands and wives (aged 30-40), by the level of schooling (college or more and less than college) of the two spouses, for the periods 1976-80 and 2001-2005. We see that in the early period, 1976-80, 56 percent of the couples for whom the wife is *more* educated than her husband followed the "traditional" division of labor whereby the husband worked full time in the market while the wife did not work at all or worked part time. In the later period, 2001-2005, this pattern is reversed with 37 percent of such couples following the traditional household roles. This switch suggests a shift from a traditional division of labor to a more efficient one. The trend of increased labor force participation of married women is observed (to a lesser degree) among other types of couples, including those for whom the husband is more educated than the wife and those for whom the spouses have the same level of education. However, the overall increase in female participation is further enhanced by the rise in the proportion of couples for whom the wife is more educated than the husband (as displayed in Figure 5) and, between spouses, by changes in the division of labor (as displayed in Figure 6).[6]

Table 1 brings evidence on the time allocation of married men and women (aged 20-59) who had young children for the years 1975 and 2003 in the United States. In both years, women spent a substantially larger amount of time than men in non-

[5] Mare (2008) uses data on *parents* of adults in the 1972-2006 General Social Survey, which allows him to estimate the trends in educational assortative matching in the United States starting at the end of the 19^{th} century. Using a log-linear representation, he finds a U-shaped time pattern whereby educational assortative mating among young couples declined up to 1950 and increased steadily thereafter.

[6] Commensurate with these changes, there has been an increase in the proportion of dual-earner couples among whom the wife outearns her husband. When educated women outnumber men, positive assortative mating can account for the higher incidence of couples among whom wives earn more than their husbands (Bloemen and Stancanelli, 2008).

market work. However, over time, the gap declined as women increased their market work and reduced their non-market work, while men reduced their market work and increased their non-market work. In 1975, married women with children 1-5 years old spent about 80 percent of their total working hours on non-market work, while this percentage for men was only 20 percent. By 2003, married women with young children had reduced their share of non-market work to 68 percent while married men had increased it to 32 percent. In 2003, the total amount of work performed by married men and women with children was quite similar, 9.35 and 8.72 hours per day, respectively.

Among the possible reasons for the changes in investment patterns of men and women are the changes in their market return to schooling and the household work that they perform. Figure 7 presents the time trends in the hourly wage differentials and hours worked by schooling for men and women in the United States. As seen in Figure 7a, women receive a higher increase in wages than men when they acquire college or advanced degrees.[7] Even when we aggregate college and advanced degrees, this female advantage remains (Figure 7b).[8] To the extent that hours of work are determined exogenously, women may receive a return for their education also in the form of increased hours of work. Figure 7c presents the impact of college or advanced degrees (compared with a high school degree) on the annual hours worked by men and women. Using Tobit regressions, we see that the proportional impact of schooling

[7] These figures are for salaried whites workers aged 25-54. Hourly wage observations of less than 2 dollars or more than 200 dollars are considered as missing. The reported coefficients are for the school level dummies in a Mincerian wage equation which is quadratic in (potential) years of experience and includes region dummies. We apply a Heckman correction to adjust for selectivity using children and marital status, as identifying variables.

[8] Similar results are reported by Gosling (2003) for Britain and Dougherty (2005) for the United States using the NLS data.

is larger for women.[9] Most men work and they raise their labor supply by about 10 percentage points when schooling is raised from high school to college or more. For women the expected number of hours (including none) rises with schooling by about 20 percentage points. However, the increase in the expected number of hours conditional on employment is smaller, indicating that the larger impact of schooling on hours among women is mainly a consequence of increased participation in the labor force. We conclude from Figures 7a through 7c that the returns to schooling in terms of wages and hours are larger for women than for men, but this advantage was declining over the period 1976-2005 as women were becoming more similar to men in terms of labor force participation.

3.2 Model Implications

Now we turn to differences between women and men that can cause them to invest at different levels according to our model. We discuss two possible sources of asymmetry: (1) In the labor market, women may receive lower wages than men, which may depress the schooling return for working women.[10] (2) In marriage, women may be required to take care of the children; this would lower the schooling return for married women. Either of these can induce women to invest less in schooling. And, according to the framework we advanced above, lower incentives of women to invest can create equilibria with mixing, where educated men are in excess supply and some of them marry less-educated women. To illustrate these effects, we shall perform two comparative statics exercises, starting from a benchmark equilibrium with strictly

[9] We control for (potential) years of experience, region dummies, children and marital status.

[10] Generally, the fact that women receive lower wages does not imply that their market return to schooling is lower. For the return to schooling, the relevant issue is whether additional schooling raises or lowers the gender gap in wages. We consider first a case in which the market return for schooling is lower for women, but shall discuss the opposite case in a subsequent section.

positive assortative matching, resulting from a complete equality between the sexes in wages and household roles. To perform these exercises, however, we need to know how differences in wages and household roles affect the gains from different marriages, as represented by z_{IJ} and ζ_{IJ} which we defined above.

3.2.1 The Household

We use a rudimentary structural model to trace the impact of different wages and household roles of men and women on marital output and surplus. We assume that, irrespective of the differences in wages or household roles, men and women have the same preferences given by

$$u = cq + \theta, \tag{23}$$

where c is a private good, q is a public good that can be shared if two people marry but is private if they remain single, and θ is the emotional gain from being married (relative to remaining single). Upon marriage, the marginal utility from the private good consumed by each spouse, c_i, equals the joint consumption of the public good, q, which is the same for both partners. Hence, utility is transferable within marriage.

The household public good is produced according to a household production function

$$q = e + \gamma t, \tag{24}$$

where e denotes purchased market goods, t is time spent working at home and γ is an efficiency parameter that is assumed to be independent of schooling.[11] Time worked at home is particularly important for parents with children. To simplify, we assume

[11] It is well known that the mother's education has strong influence on child quality (see Behrman, 1997). However, our qualitative results will be unaffected as long as schooling has a larger effect on market wages than on productivity at home. Such an assumption is consistent with the strong positive effect of education on the number of hours worked by women, which we alluded to in section 3.1.

that all married couples have one child and that rearing it requires a specified amount of time $t = \tau$, where τ is a constant such that $0 \leq \tau < 1$. Initially, we shall assume that all the time provided at home is supplied by the mother due to social norms. Also, individuals who never marry have no children and for them we set $\tau = 0$.

If man i of class I with wage $w^m_{I(i)}$ marries woman j of class J with wage $w^w_{J(j)}$, their joint income is $w^m_{I(i)} + (1-\tau)w^w_{J(j)}$. With transferable utility, any efficient allocation of the family resources maximizes the partners' sum of utilities given by $[w^m_{I(i)} + (1-\tau)w^w_{J(j)} - e](e + \tau\gamma) + \theta_i + \theta_j$. In an interior solution with positive expenditure on the public good, the maximized material output is

$$\zeta_{ij} = \frac{[w^m_{I(i)} + \tau\gamma + (1-\tau)w^w_{J(j)}]^2}{4}. \tag{25}$$

Note that the wages of the husband and wife complement each other in generating marital output, which is a consequence of sharing the public good.[12]

An unmarried man i solves

$$\underset{e_i, c_i}{Max} \;\; c_i e_i \tag{26}$$

subject to

$$c_i + e_i = w^m_{I(i)}, \tag{27}$$

and his optimal behavior generates a utility level of $\zeta_{i0} = (w^m_{I(i)}/2)^2$. A single woman j solves an analogous problem and obtains $\zeta_{0j} = (w^w_{J(j)}/2)^2$. Therefore, the total *marital surplus* generated by the marriage in the second period is

[12] The first-order condition for e is

$$[w^m_{I(i)} + (1-\tau)w^w_{J(j)} - e] - (e + \tau\gamma) \leq 0.$$

Hence, $e = [w^m_{I(i)} + (1-\tau)w^w_{J(j)} - \tau\gamma] \,/\, 2$ in an interior solution. The maximized material output in this case is $[w^m_{I(i)} + \tau\gamma + (1-\tau)w^w_{J(j)}]^2 \,/\, 4$. If $e = 0$, the maximal material output is $[w^m_{I(i)} + (1-\tau)w^w_{J(j)}]\tau\gamma$, which would imply an additive surplus function, contradicting our assumption of complementarity. A sufficient condition for a positive e is $w^m_1 + (1-\tau)w^w_1 > \tau\gamma$ if the wife works at home and $w^w_1 + (1-\tau)w^m_1 > \tau\gamma$ if the husband works at home. We assume hereafter that these conditions hold.

$$z_{ij} = \frac{[w^m_{I(i)} + \tau\gamma + (1-\tau)w^w_{J(j)}]^2 - (w^m_{I(i)})^2 - (w^w_{J(j)})^2}{4}. \quad (28)$$

The surplus of a married couple arises from the fact that spouses jointly consume the public good. If they have no children and $\tau = 0$, the gains arise solely from the pecuniary expenditures on the public good. In this case, the surplus function is *symmetric* in the wages of the two spouses. If the couple has a child, however, and the mother takes care of her, then the mother's contribution to household output is a weighted average of her market wage and productivity at home. We assume that $w^w_2 > \gamma > w^w_1$ so that educated women are more productive in the market and uneducated women are more productive at home. The surplus function in (28) maintains complementarity between the wages of the husband and the wife, which is a consequence of sharing the public good. However, the assumed asymmetry in household roles between men and women implies that a higher husband's wage always raises the surplus but a higher mother's wage can reduce it. In other words, it may be costly for a high-wage woman to marry and have a child because she must spend time on child care, while if the woman does not marry, her utility as a single remains $w^2_{J(j)}/4$. In addition, it is no longer true that $z_{21} = z_{12}$.[13]

As long as one assumes that, due to social norms, all the time provided at home is supplied by the mother, all the gains from marriage arise from sharing a public good and the wages of the partners complement each other so that $z_{11} + z_{22} > z_{12} + z_{21}$. If the division of labor is determined efficiently and the partners assign the spouse with the lower wage to take care of the child, complementarity continues to hold for

[13]For instance, when the wages of men and women are equal but $\tau > 0$, we have

$$z_{21} - z_{12} = \frac{\tau(w_2 - w_1)}{2}[(1-\tau)\frac{w_2 + w_1}{2} + \tau\gamma] > 0.$$

sufficiently low time requirements, i.e., τ close to 0. However, for τ close to 1, the wages of the two partners become substitutes, that is, $z_{11} + z_{22} < z_{12} + z_{21}$, because wage differentials between spouses increase the gains from specialization (see Becker, 1991, ch. 2). Thus, whether couples act efficiently or according to norms influences the equilibrium patterns of assortative mating.[14]

3.2.2 The Impact of the Wage Gap

We are now ready to examine the impact of gender differences in market wages or household roles on the decisions to invest and marry and the equilibrium in the marriage market.

Start from a benchmark of complete equality between the sexes in wages and household roles such that $w_1^m = w_1^w = w_1$, $w_2^m = w_2^w = w_2$ and $\tau = 0$, yielding an equilibrium with strictly positive assortative mating and equal shares (point e in Figure 2). Now examine the impact of an increase in the wage of educated men, w_2^m, combined with a reduction in the wage of educated women, w_2^w, holding the wage of uneducated men at the benchmark value, w_1. To isolate the role of market returns, assume that the increase in the wage of educated men exactly compensates the reduction in the wage of educated women so that marital output is unaffected and symmetry is maintained. In other words, the wage changes affect directly only the returns as singles, R^m and R^w. Men's higher market return to schooling encourages

[14] Let $w_2^m > w_2^w > w_1^m$ and define

$$
\begin{aligned}
f(\tau) &\equiv 4(z_{11} + z_{22} - z_{12} - z_{21}) \\
&= [w_1^m + \tau\gamma + (1-\tau)w_1^w]^2 + [w_2^m + \tau\gamma + (1-\tau)w_2^w]^2 \\
&\quad -[w_2^w + \tau\gamma + (1-\tau)w_1^m)]^2 - [w_2^m + \tau\gamma + (1-\tau)w_1^w]^2.
\end{aligned}
$$

Then, $f(\tau) > 0$ if $\tau = 0$ and $f(\tau) < 0$ if $\tau = 1$, where $\forall\ \tau \in [0,\, 1]$, $f'(\tau) < 0$.

their investment in schooling and also strengthens their incentives to marry, because schooling obtains an additional return within marriage. In contrast, women's lower return to schooling reduces their incentives to invest and marry. These alterations create excess supply of men who wish to invest and marry. Consequently, to restore equilibrium, the rates of returns that men receive within marriage must decline implying that, for any V_1, the value of V_2 that satisfies conditions (21) and (22) must decline.

For moderate changes in wages, strictly positive assortative mating continues to hold. However, the equilibrium value of V_2 declines and educated men receive a *lower* share of the surplus in any marriage than they do with equal wages. That is, as market returns of men rise and more men wish to acquire education, the marriage market response is to reduce the share of educated men in *all* marriages. When the gap between R^m and R^w becomes large, the equilibrium shifts to a mixed equilibrium, such that the return from schooling of men is at its lower bound and some educated men marry uneducated women (at point $e\prime$ in Figure 3). Both V_1 and V_2 are lower in the new equilibrium so that *all* men (women), educated and uneducated, receive lower (higher) shares of the material surplus when men have stronger market incentives to invest in schooling than women.

These results regarding the shares of married men and women in material *surplus* must be distinguished from the impact of the shares in material *output.* If men get a higher return from schooling as singles (due to the fact that their labor-market return to schooling is higher than that of women), then their share of the material output can be higher even though they receive a lower share of the surplus. The same remark applies to our subsequent analysis as well; one can obtain sharper comparative static results on shares of the material surplus than those on shares of material output.

3.2.3 The Impact of Household Roles

To investigate the impact of household roles, we start again at the benchmark equilibrium and examine the impact of an increase in τ, holding the wages of men and women at their benchmark values, that is $w_1^m = w_1^w = w_1$ and $w_2^m = w_2^w = w_2$. Initially, assume that due to norms the wife alone spends time on child care. Then an increase in the time requirements for child care, holding γ constant, reduces the contribution that educated women make to marital output and raises the contribution of uneducated women. That is, z_{11} and z_{21} rise because uneducated women are more productive at home, $\gamma > w_1$, while z_{12} and z_{22} decline because educated women are less productive at home, $\gamma < w_2$. Consequently, both equilibrium lines corresponding to conditions (21) and (22) shift down so that V_2 is lower for any V_1 and the analysis is the same as in the previous case. The only difference is that the boundaries on the rate of returns from schooling that men can obtain within marriage shift as $z_{21} - z_{11}$ rises and $z_{22} - z_{12}$ declines.

For moderate changes in τ, strictly positive assortative mating with equal sharing continues to hold. As long as a symmetric equilibrium is maintained, the returns to schooling that men and women receive within marriage, $V_2 - V_1$ and $U_2 - U_1$, are equal. Hence, men and women have the same incentives to invest. But because the material surplus (and consequently utilities within marriage) of educated men and women, $z_{22}/2$, declines with τ, while the material surplus of uneducated men and women, $z_{11}/2$, rises, both men and women reduce their investments in schooling by the same degree.

As τ rises further, the difference in the contributions of men and women to marriage can rise to the extent that an educated man contributes to a marriage with uneducated woman more than an educated woman contributes to a marriage with an educated man. That is, $z_{21} - z_{11} > z_{22} - z_{21}$, implying that the *lower* bound on the return to schooling that men receive within marriage exceeds the *upper* bound on the return to schooling that women receive within marriage.[15] In this event, the symmetric equilibrium is eliminated and instead there is a mixed equilibrium with some educated men marrying uneducated women. This outcome reflects the lower incentive of educated women to enter marriage and the stronger incentive of men to invest because their return from schooling within marriage, $V_2 - V_1 = z_{21} - z_{11}$, exceeds the return to schooling that women can obtain in marriage. Consequently, some educated men must "marry down" and match with uneducated women.

An important idea of Becker (1991, ch. 2) is that wage differences among identical spouses can be created endogenously and *voluntarily* because of learning by doing and increasing returns. Thus, it may be *optimal* for the household for *one* of the spouses to take care of the child and for the other to enter the labor market. Because we assume transferable utility between spouses, household roles will be determined efficiently by each married couple as long as there is ability to commit to a transfer scheme, whereby the party that sacrifices outside options when he\she acts in a manner that raises the total surplus is compensated for his/her action. In the previous analysis, there was no need for such a commitment because the division of the surplus was fully determined by attributes that were determined prior to marriage via competition over mates who could freely replace partners. However, if time spent on child care affects one's labor

[15] Equal wages of men and women imply $z_{12} = z_{21}$ and

$$\begin{aligned} h(w_1, w_2, \tau) \; &\equiv 2z_{21} - z_{11} - z_{22} = 2[w_2 + \tau\gamma + (1-\tau)w_1]^2 \\ &-[w_1 + \tau\gamma + (1-\tau)w_1]^2 - [w_2 + \tau\gamma + (1-\tau)w_2]^2. \end{aligned}$$

For w_1 slightly below γ and w_2 slightly above γ, $h(w_1, w_2, \tau) > 0$. The larger is τ, the broader will be the range in which $h(w_1, w_2, 0) > 0$.

market wages subsequently, the cost of providing child care can differ between the two spouses. Then, implementing the efficient outcome might require some form of *commitment* even if (re)matching is frictionless (see Lundberg and Pollak, 1993, and Chiappori, Iyigun, Weiss, 2008). A simple, enforceable, prenuptial contract is one in which both partners agree to pay the equilibrium shares V_I to the husband and U_J to the wife in case of divorce. By making those shares the relevant threat points of each spouse, this contract sustains the equilibrium values V_I and U_J in marriage, which is sufficient to attain the efficient household division of labor.

If there is discrimination against women in the labor market and they receive lower wages than men, partners that act efficiently will typically assign the wives to stay at home, which will erode their future market wages and reinforce the unequal division of labor. Similarly, if there are predetermined household roles such that women must take care of their child, then women will end up with lower market wages. Thus, inequality at home and the market are interrelated (see Albanesi and Olivetti, forthcoming, and Chichilnisky, 2005).

3.3 Why Women May Acquire More Schooling than Men

We have examined two possible reasons why women may invest differently from men: difference in market returns for schooling and difference in the returns for schooling within marriage. We now proceed to more specific assumptions to address the puzzling reversal in the gender differences in schooling starting in about 1980. Consider a comparison of the following two situations. An "old" regime in which married women must spend a relatively large fraction of their time at home and a "new" regime in which, because of reductions in fertility and improved technology in home production, married women spend less time at home and work more in the market (Greenwood et al., 2005, Albanesi and Olivetti, forthcoming). Assume further that women suffer from statistical discrimination because employers still expect them to invest less on the job; however, discrimination is weaker against educated women because they are expected to stay longer in the labor market than uneducated women. Finally, assume that in the old regime norms were relevant but in the new regime household roles are determined efficiently. It is then possible that in the new regime women will invest in schooling *more* than men.[16]

In Figure 8a, we display the transition between the two regimes. We assume that discrimination against women is lower at the higher level of schooling in both regimes. However, in the old regime, women must spend a substantial amount of time working at home, implying that, within marriage, women receive lower returns to schooling than men. Thus, men have stronger incentives to acquire schooling. To sharpen our result, we assume a mixed initial mixed equilibrium (point $e\prime$ in Figure 8a) such that the return that men receive within marriage is at the *lower* bound and some educated men marry uneducated women. We then reduce the amount of time spent at home production, τ, and raise the productivity at home, γ. We also raise the labor-market returns of men and women (i.e. increase w_2^w/w_1^w and w_2^m/w_1^m). These changes, together with the change in norms, strengthen the incentives of women to invest in schooling and to marry more than they do for men. Therefore, holding V_1 constant, an increase in V_2 relative to V_1 is required to maintain equality between the number of men who wish to invest and marry and the number of women who wish

[16]Models of statistical discrimination tie household roles and market wages through employers' beliefs about female participation. Typically, such models generate multiple equilibria and inefficiency (Hadfield, 1999, Lommerud and Vagstad, 2002). Here, we do not require employers' beliefs to be correct. Instead, we think of household roles and discrimination as processes that evolve slowly and can be taken as exogenous in the medium run.

to invest and marry. Thus, the equilibrium line in Figure 8a shifts upward.[17] The impact of a lower τ and the higher education premium are assumed to be large enough to generate a new mixed equilibrium in which the return from schooling that men can receive within marriage is at the upper bound, implying that women receive the lower bound on the return for schooling within marriage. This new mixed equilibrium is indicated by point e'' in Figure 8a.

The comparative statics between points e' and e'' are actually quite subtle. A first effect is that educated men are now in short supply, a beneficial change for them (they now receive the upper bound compatible with the new equilibrium). However, that's only part of the story. With the decline in the time requirement of home production, the contribution of educated women to the marital surplus rises, regardless of whom they marry. In addition, under the new regime, some educated women marry uneducated men. For such couples, both the marital surplus and the surplus share that uneducated men receive within marriage increase, because the demand for uneducated men has risen. This, in turn, produces a higher marital surplus share for all uneducated men. In contrast, these specific gains do not directly affect uneducated women who may actually lose from the change in regime. Moreover, if we consider changes in the specialization patterns within the household, men are increasingly less likely to be the bread-winners when married to educated women and their marriage-market incentive to invest in schooling rises even less. In the simulations used here, we find that the marriage-market returns to education increase

[17] Recall that in our model, the contribution of a woman who works at home to the marital surplus depends on $\tau\gamma + (1-\tau)w^w_{J(j)}$. Given our assumption that $w^w_2 > \gamma > w^w_1$, a decrease in τ raises (reduces) the contribution of educated (uneducated) women. In contrast, an increase in γ raises the contributions of *all* married women. To make comparisons easier, we chose parameters such that z_{11} is the same in the two regimes. For full details on the simulations used to generate Figures 8a and 8b, see the online Appendix.

much more for women than they do for men, primarily because of the asymmetric effect of the regime switch on uneducated men and women respectively. This result is illustrated in Figure 8b, which details the respective shares of total surplus received by each spouse; all spousal marital surplus shares are higher, except for that of uneducated wives.

In response to changes in the equilibrium surplus shares that men and women receive, agents modify their investment and marriage choices. Simple simulations show that the increase in the proportion of women who are willing to invest in schooling exceeds the increase in the proportion of men who wish to invest. In addition, the proportion of educated women that marry rises as educated women are released from household chores (see the on line Appendix).

4 Conclusion

In standard models of human capital, individuals invest in schooling with the anticipation of being employed at a higher future wage that would compensate them for current foregone earnings. In this paper, we add another consideration: the anticipation of being married to a spouse with whom one can share consumption and coordinate work activities. Schooling has an added value in this context because of complementarity between agents, whereby the contribution of the agents' schooling to marital output rises with the schooling of their spouses. In the frictionless marriage market considered here, the matching pattern is fully predictable and supported by a unique distribution of marital gains between partners. That distribution is governed by competition, because for each agent there are perfect substitutes that can replace him\her in marriage. This simple framework allows us to jointly determine investment and marriage patterns as well as the welfare of men and women under a variety of circumstances.

From the perspective of family economics, gender differences in investment in schooling are of particular interest because assortative matching based on schooling is a common feature of marriage patterns in modern societies. However, schooling is an acquired trait that responds to economic incentives. In terms of our model, the main reason for women's lower investment in schooling in the past was the large amount of household work that was imposed on them upon marriage, which reduced the return from schooling *within marriage*. Two major evolutions took place during recent decades: the market rate of return to schooling has increased for both men and women and technological progress has freed women from many domestic tasks. The latter effect, through its impact on the gains from marriage and its division at equilibrium, can explain why the overall returns to schooling has increased more for women than for men. The same considerations also explain why educated women are more inclined to marry now than in the past. Finally, discrimination against women appears to be weaker at higher levels of schooling. This is a possible explanation for the slightly higher investment in schooling by women that we observe today. We do not view this outcome as a permanent phenomenon but rather as a part of an adjustment process, whereby women who now enter the labor market in increasing numbers, following technological changes at home and in the market that favor women, must be "armed" with additional schooling to overcome norms and beliefs that originated in the past.

From the perspective of labor economics, the introduction of family considerations can broaden our analysis of the incentive to invest in human capital. Early work by Mincer and Polachek (1974) provided explanations for the gender wage gap even in the absence of any discrimination based on lower investments on the job resulting from expected interruptions in labor force participation. At that time, women also acquired less schooling. The current reversal in the schooling gender gap poses a challenge to this approach.

An important issue in the literature is whether premarital investments in education are efficient. In markets with frictions or small number of traders are usually characterized by inefficient premarital investments (Lommerud and Vagstad, 2000, Baker and Jacobsen, 2007). However, in our model with many agents and no frictions, the marital shares that individuals expect to receive within marriage induce them to fully internalize the *social* gains from their premarital investments and investments are efficient (see Browning et al., forthcoming, ch. 12, Cole et al., 2001, Peters and Siow, 2002 and Iyigun and Walsh, 2007).

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Figure 1: Regions for Marriage and Investment

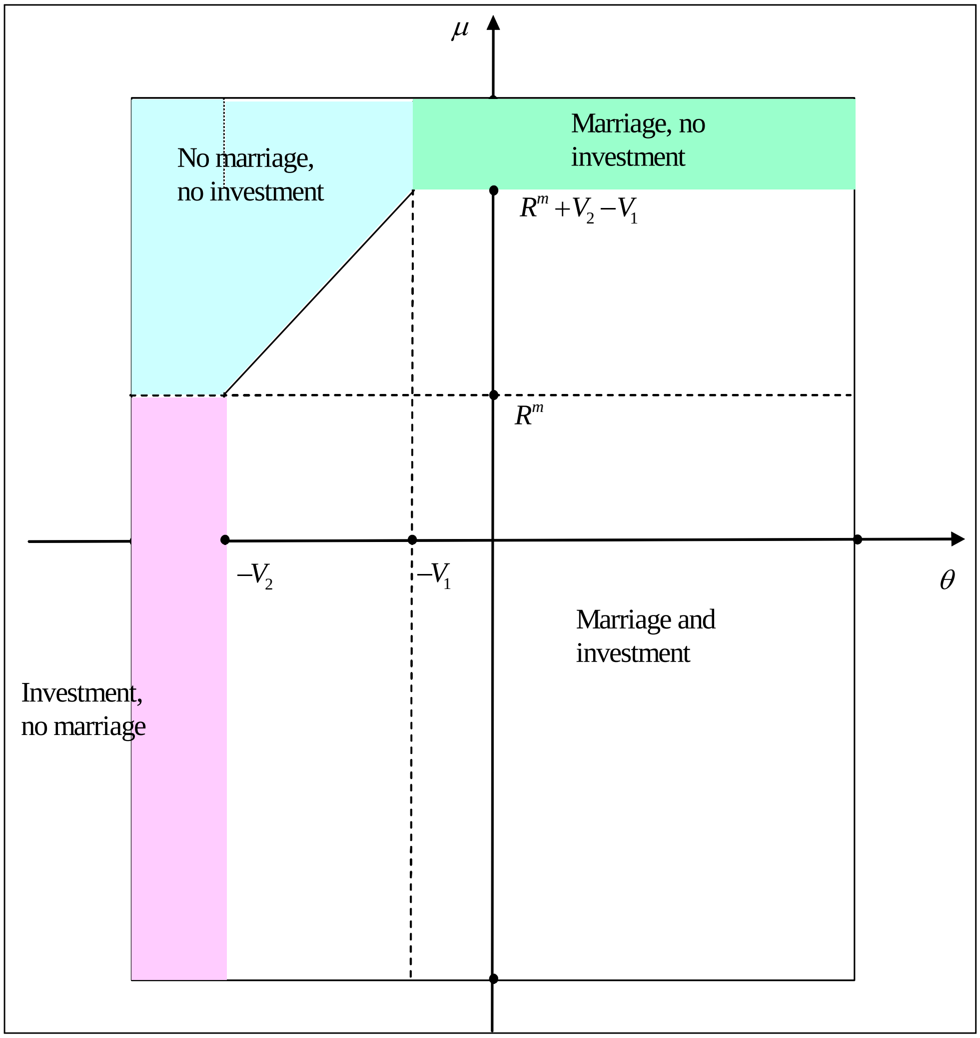


Figure 2: Equilibrium with Strictly Positive Assortative Matching

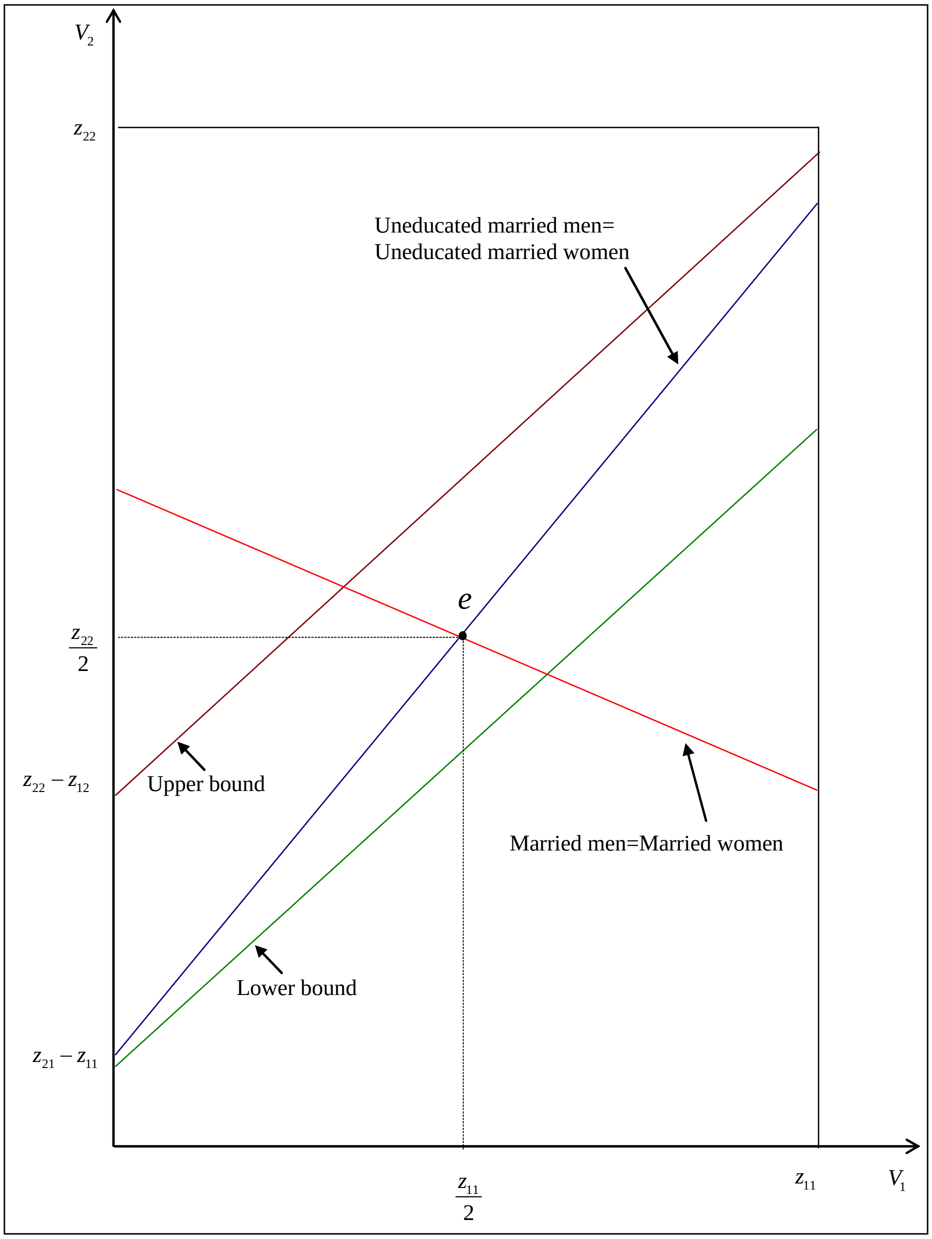


Figure 3: Mixed Equilibrium with More Educated Men than Educated Women

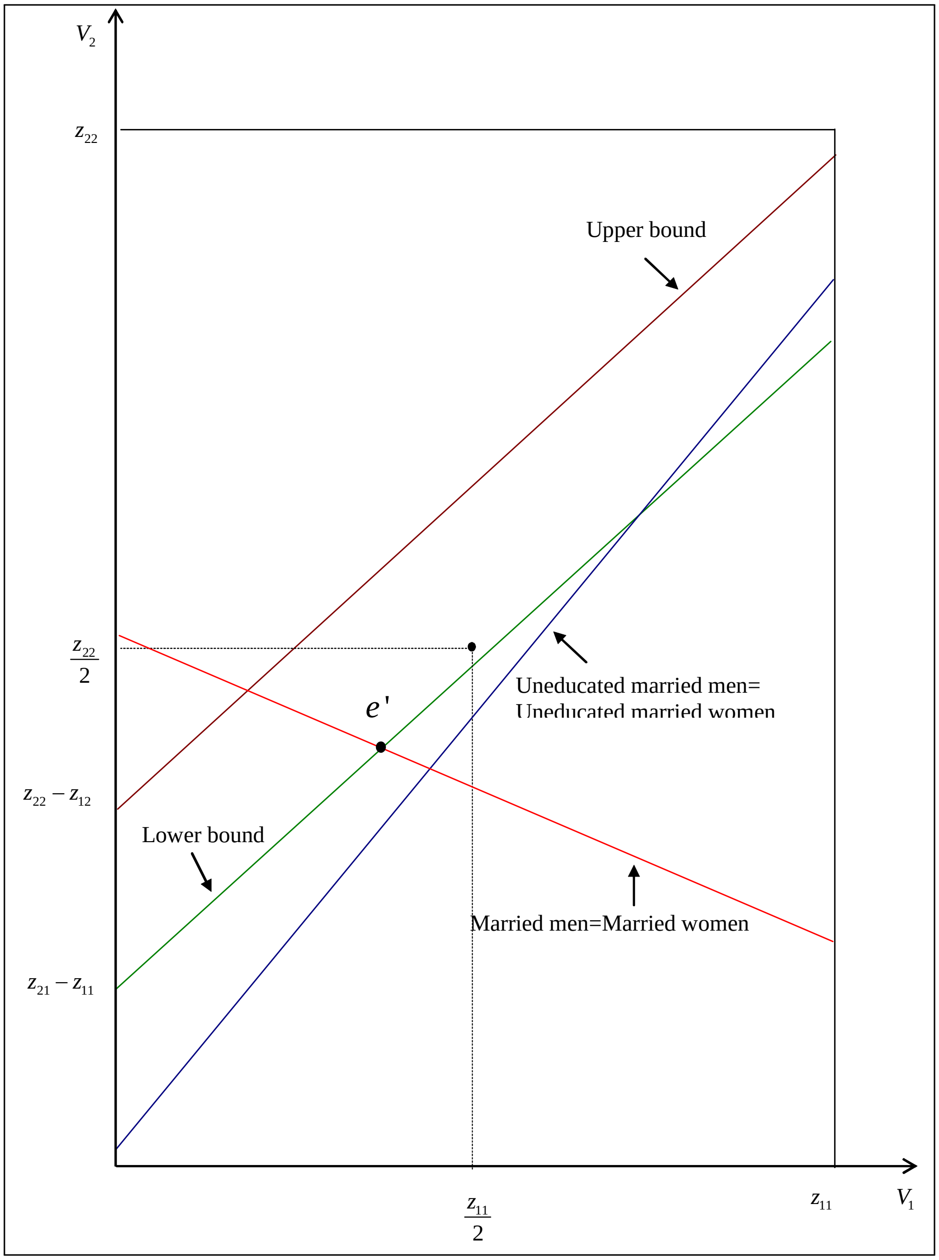
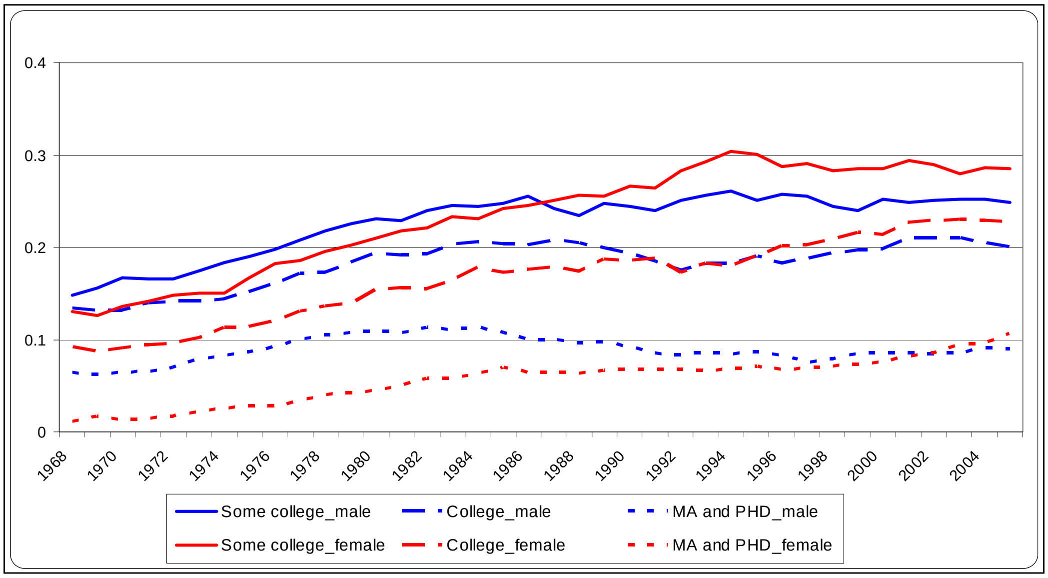
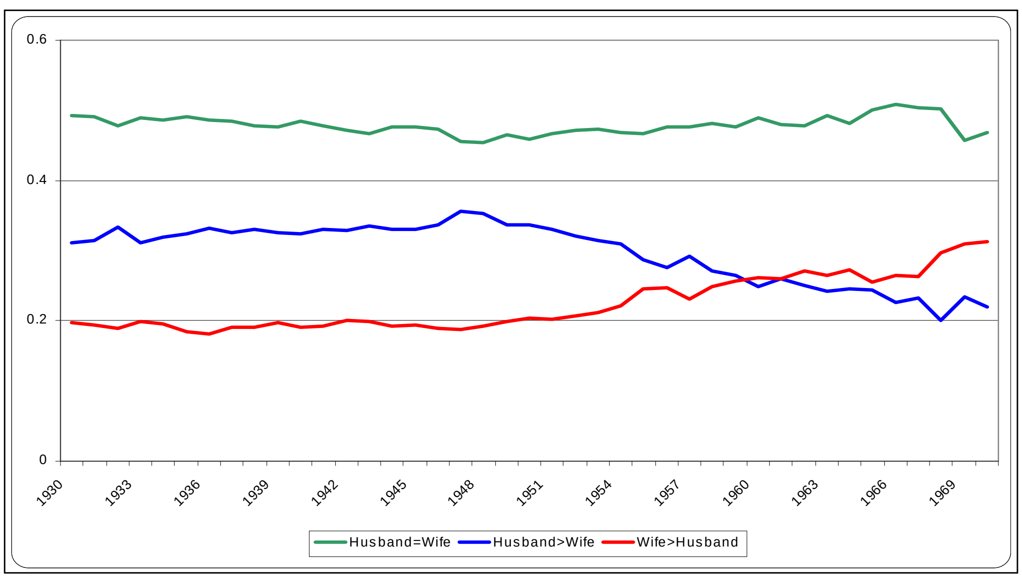


Figure 4: Completed Education by Sex, 30-40 years old, US 1968-2005 (CPS)



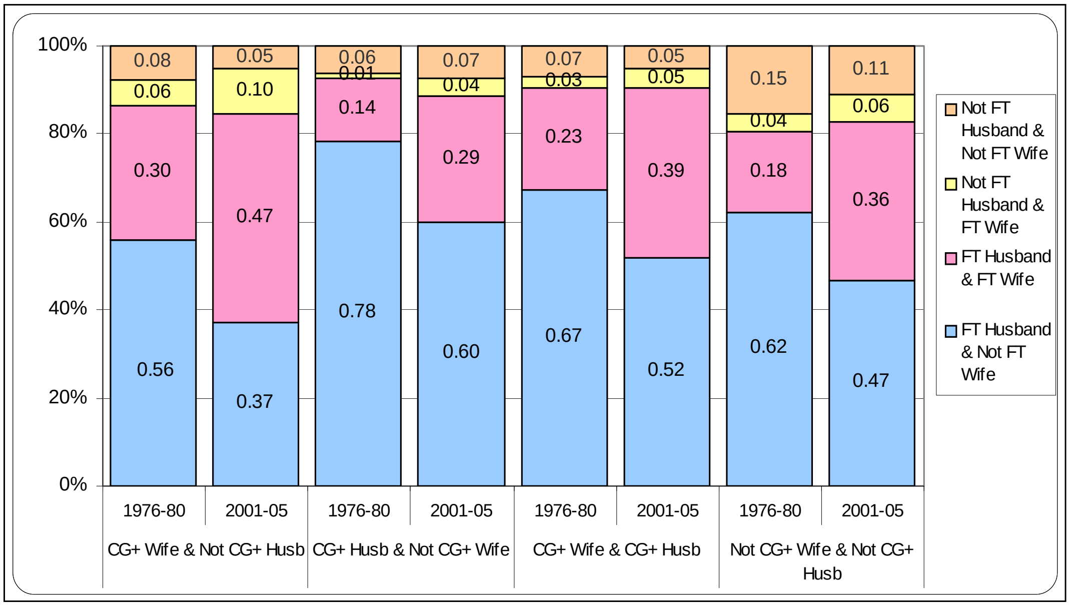
Source: Current Population Surveys.

Figure 5: Educational Attainment of Spouses by Husbands' Year of Birth (United States)

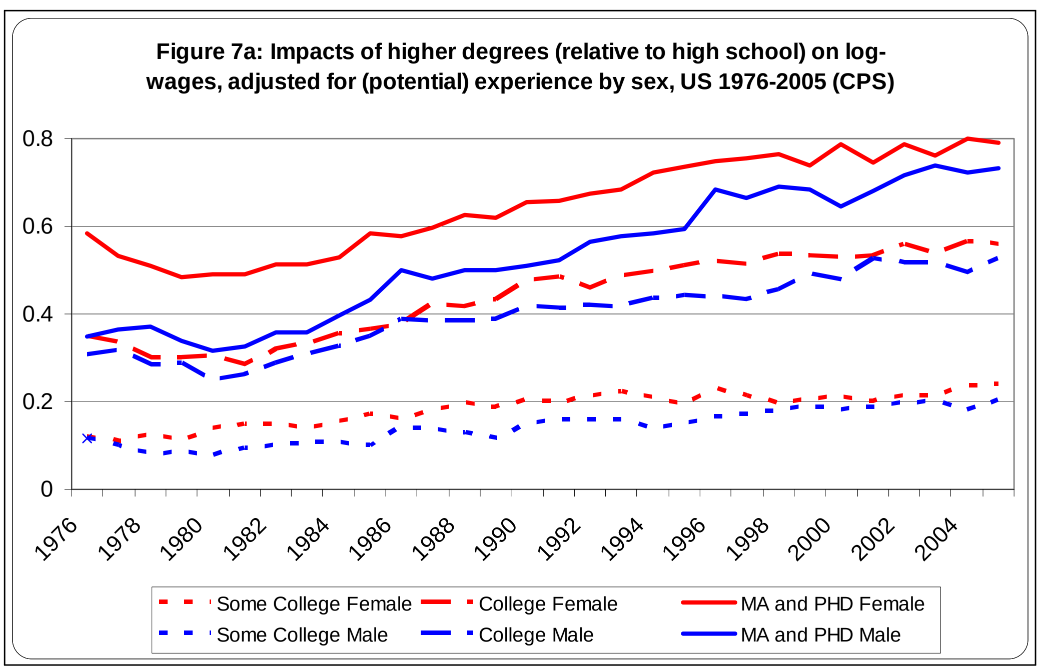


Source: Current Population Surveys.

Figure 6: Couples' Work Patterns by Spousal Education, Ages 30-40, U. S., 1976-80 and 2001-05



Source: Current Population Surveys.



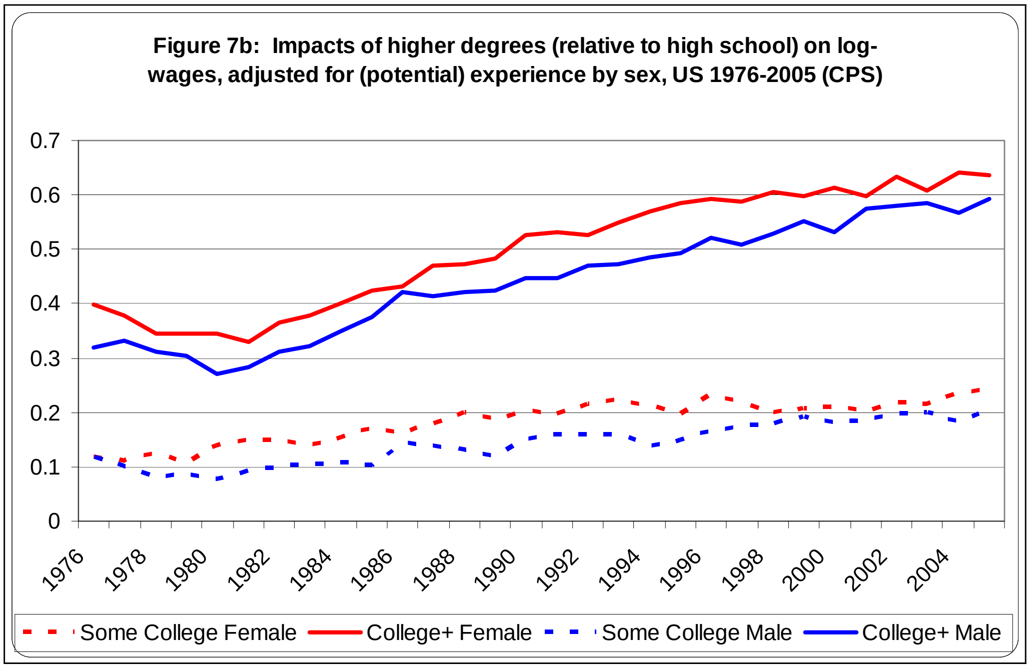


Figure 7b: Impacts of higher degrees (relative to high school) on log-wages, adjusted for (potential) experience by sex, US 1976-2005 (CPS)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Some College Female
College+ Female
Some College Male
College+ Male

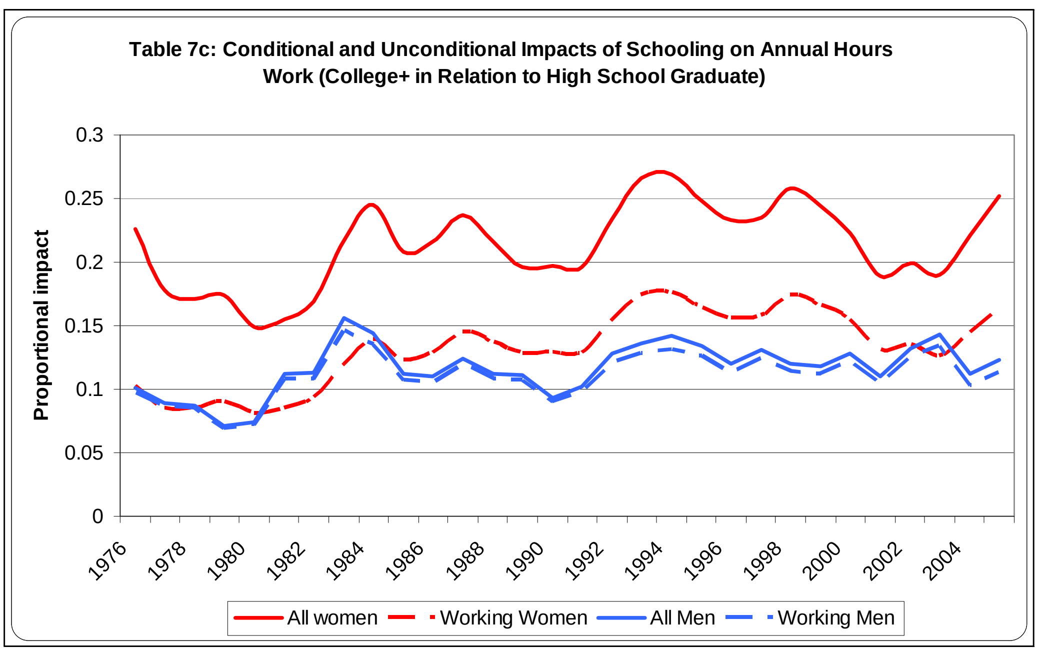


Table 7c: Conditional and Unconditional Impacts of Schooling on Annual Hours Work (College+ in Relation to High School Graduate)
Proportional impact
0.3
0.25
0.2
0.15
0.1
0.05
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
All women
Working Women
All Men
Working Men

Figure 8a: The Impact of a Decrease in the Wife's Work at Home Combined with an Increase in the Wage of Educated Women (Equilibrium)

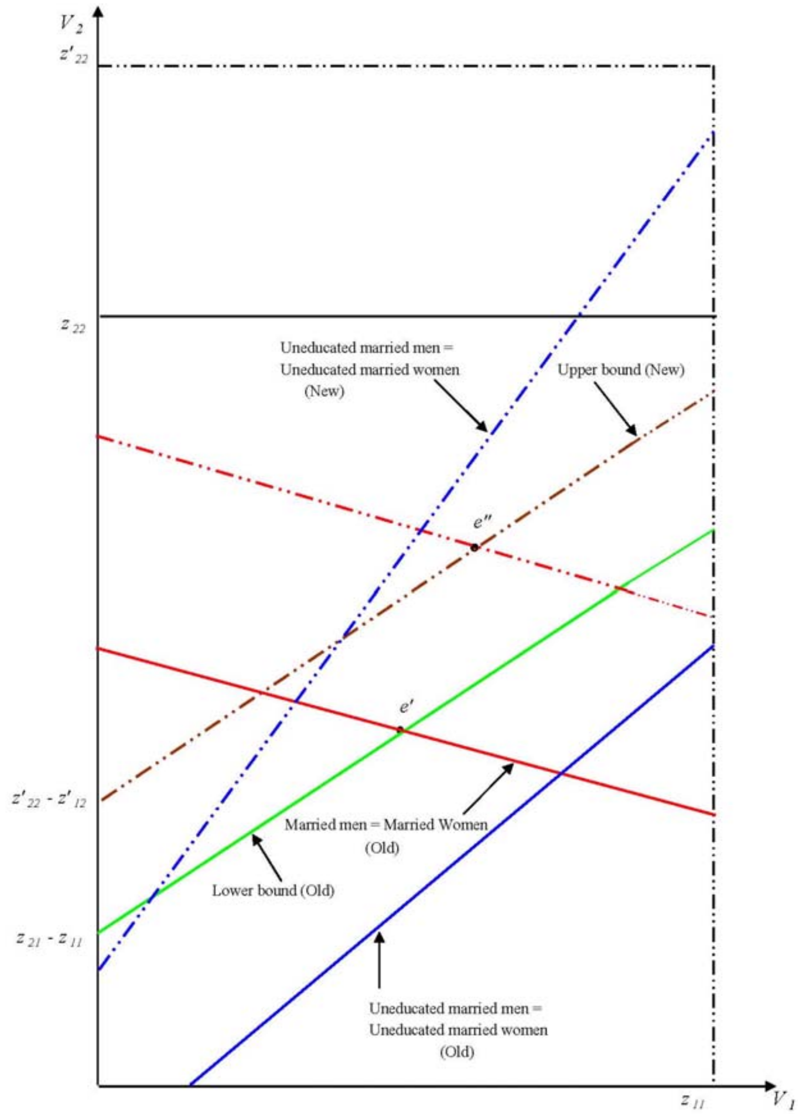


Figure 8b: The Impact of a Decrease in the Wife's Work at Home Combined with an Increase in the Wage of Educated Women (New and Old Surplus Spousal Shares)

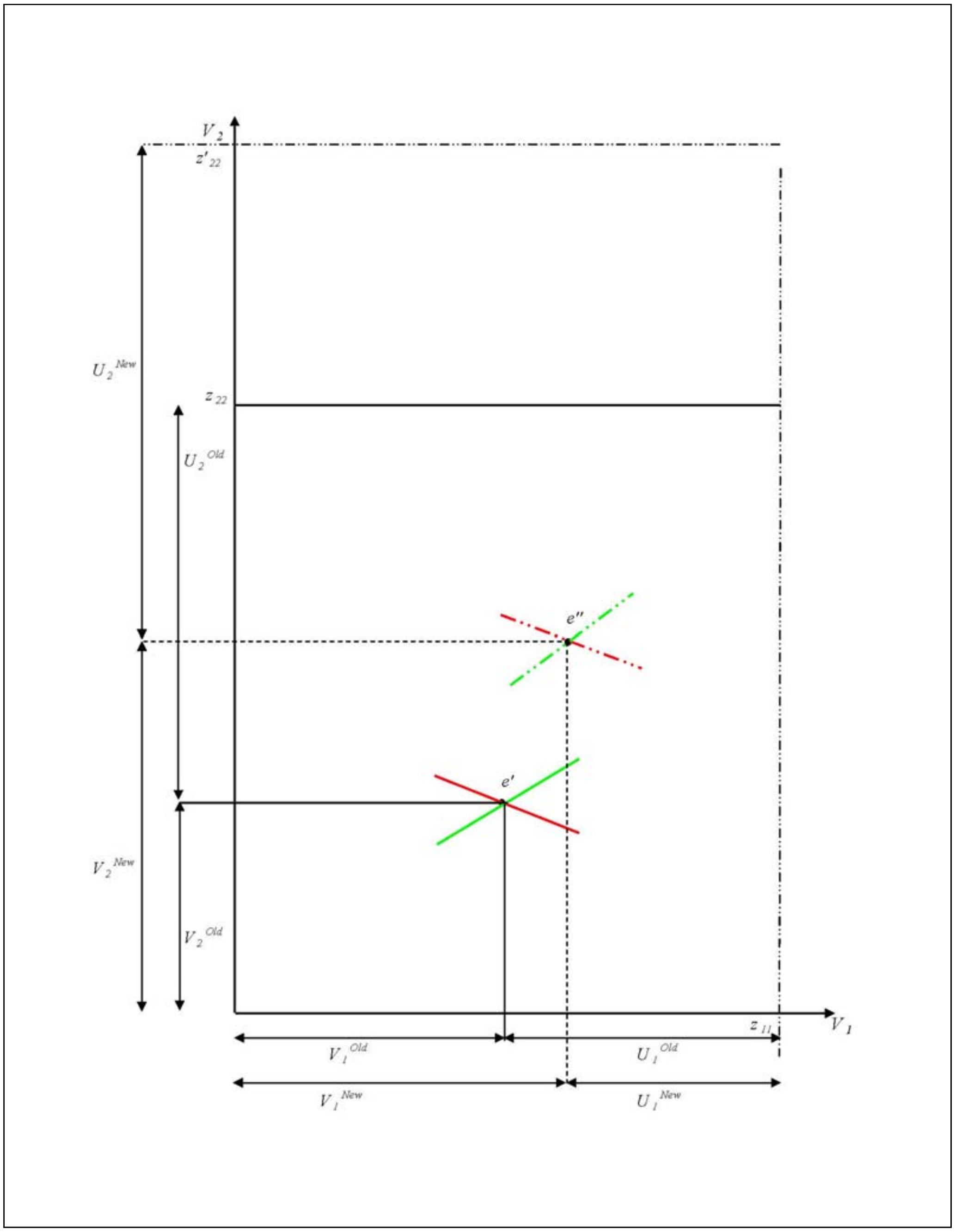


Table 1: Time Use (hours per day) of US Married Men and Women with Children

	1975		2003	
	Women	Men	Women	Men
Paid work				
Child <5	1.55	6.98	2.81	6.39
Child 5-17	2.71	7.17	3.68	6.40
Household Work				
Child <5	3.67	1.10	2.64	1.38
Child 5-17	3.63	1.18	2.83	1.52
Child Care				
Child <5	1.63	0.40	2.67	1.24
Child 5-17	0.65	0.20	1.13	0.57
Shopping				
Child <5	0.50	0.28	0.60	0.39
Child 5-17	0.59	0.24	0.61	0.34
Leisure				
Child <5	5.98	5.43	5.01	4.93
Child 5-17	6.14	5.38	5.61	5.49

Source: American's Use of Time (1975) & Time Use Survey (2003).