The Effect of Bargaining in Marriage on Human Capital Accumulation

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Abstract

When bargaining occurs within a marriage and bargaining positions are determined by unmarried income potential, agents should accumulate higher levels of human capital than they would given market returns only. Past work on life-cycle human capital decisions either does not model bargaining in the marriage or only describes theoretical outcomes of bargaining without making empirical measurements. I construct a multi-period model of education, labor market, and marriage decisions in which agents account for the bargaining environment of marriage. After estimating parameters using data moments, I measure the additional education and labor hours induced by bargaining in the marriage. The results suggest that the incentive to maintain a higher bargaining position can account for almost 55 hours of labor annually and over 2 years of schooling during the first 12 years of adulthood.

1 Introduction

Returns to human capital are traditionally thought to accrue in the form of higher lifetime wages, either due to increased worker productivity or the signalling of a hidden type (e.g., worker ability). Despite this view, a large portion of the population, primarily women, accumulate high levels of human capital but do not spend significant time in the labor force where the investment would yield its returns. As of 2012, of those mothers of children under 18 with a college degree (and no more), 25 percent were not working. Over a third of mothers who had spent some time in college stayed home (Gallup). The resource allocation problem within households offers one possible explanation of this behavior.

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The traditional view of the household as a single, indivisible unit does not necessarily capture the dynamics of resource decisions negotiated among household members. Moving toward a more flexible household model, Ashenfelter and Heckman [1974] and many others have incorporated the idea of optimizing over multiple members in the household. In its most basic form, this approach takes the household to be a single agent that maximizes shared utility by allocating work and leisure between household members. Subsequent work has expanded on this idea and developed models of households as groups of agents who optimize subject to the constraints of the household. Manser and Brown [1980] and McElroy and Horney [1981] introduce bargaining to the household allocation problem.

In 1950, John Nash introduced the simple yet elegant bargaining solution of maximizing the product of individual surpluses. In the presence of Nash bargaining in the household, the determinants of each spouses' bargaining position will almost certainly drive behavior. Because the outside option in marriage is divorce, it is reasonable to assume that expected utility when single dictates bargaining positions. A higher level of human capital, to the extent that it affects one's earnings potential, should thus improve one's bargaining position. Individuals may therefore be motivated to accumulate what would otherwise appear to be non-optimal levels of human capital, both before and during marriage.

Chiappori et al. [2009] present a similar theoretical framework in which human capital has returns in wages and marital surplus extraction. However, their primary focus is a theoretical equilibrium and as a consequence their model is not easily taken to data. Gould [2008] estimates a structural model in which human capital increases the chances of receiving a marriage proposal and finds significant effects among men. His analysis does not include women, and the returns in the marriage market come only through more proposals rather than the more complex effects modeled in this paper. Nosaka [2007], in a more abstract sense, considers the impact of human capital on the marriage market and marital utility, for both men and women. However, the two effects are modeled as competition and specialization without much design on the actual processes that produce these incentives.

In light of the above observations, I begin by building a two-period model in which agents optimize during younger years with the knowledge that human capital will determine allocations during marriage. Savings and borrowing are not included as they further enlarge an already burdensome state space. During the second period, agents choose whether to marry based on a single random arrival from the distribution of the opposite gender. Human capital also determines the probably of marriage since a higher outside option can reduce or eliminate the possibility of marriage creating a surplus. Within the marriage, Nash bargaining determines the division of the surplus due to the coupling. The model in solved repeatedly until two stationary distributions (one for each gender) are generated.

When possible, parameters for the model are calculated directly. Those for which this cannot be done are estimated by simulated method of moments. In both cases, the primary data source is the National Longitudinal Survey of Youth 1979 (NLSY '79). By considering an alternative split of the household surplus, I attempt to measure the additional education and labor hours induced by bargaining in the marriage. The results suggest that the incentive to maintain a higher bargaining position can account for almost 55 hours of labor annually and over 2 years of schooling during the first 12 years of adulthood.

2 The Two-Period Model

2.1 Environment

Consider two equally sized masses of agents who ex-ante identical with the exception that they can only match with an agent from the opposing mass. An agent lives for two periods. During the first period (ages 16 to 27), agents are solitary and choose, after seeing initial human capital (h_1) and a wage shock (ε), a time allocation across schooling, labor, and leisure. There is no saving or borrowing.

At age 28, new human capital (h_2) comes online (which was produced during the first period) while the wage shock from period 1 carries over. A fraction θ of agents match randomly with one agent from the opposing mass and draw a shared (within the potential match) marital utility η. The agents remain matched during the second period (ages 28-65) if both agents find the match weakly better than the alternative of spending the period alone.

If a pair of agents remains matched, their income is pooled, and they choose an allocation of labor, leisure, and consumption via Nash bargaining. Their respective bargaining positions are determined by their utility levels in the alternative case of being single. Agents who remain single choose levels of labor and leisure as they did during the first period. At age 65, all agents die.

Notationally, we can define the outcome of the Nash bargaining in marriage by

$$\begin{aligned}\{c_{2,m}(h_2,\varepsilon,\tilde{h}_2,\tilde{\varepsilon},\eta),\bar{n}_2-\ell_{2,m}(h_2,\varepsilon,\tilde{h}_2,\tilde{\varepsilon},\eta),\tilde{n}_{2,m}\} = \\ \arg\max_{c\geq 0,\{n,\tilde{n}\}\in[0,\bar{n}_2]^2}(u_{2,m}(c,\bar{n}_2-n,\eta)-d)(u_{2,m}([w_2h_2\varepsilon]n+[w_2\tilde{h}_2\tilde{\varepsilon}]\tilde{n}-c,\bar{n}_2-\tilde{n},\eta)-\tilde{d})\end{aligned}$$

subject to

$$u_{2,m}(c,\bar{n}_2-n)-d\geq 0$$

$$u_{2,m}([w_2h_2\varepsilon]n+[w_2\tilde{h}_2\tilde{\varepsilon}]\tilde{n}-c,\bar{n}_2-\tilde{n})-\tilde{d}\geq 0$$

$$d=\max_{n\in[0,\bar{n}_2]}u_{2,s}([w_2h_2\varepsilon]n,1-n)$$

$$\tilde{d}=\max_{\tilde{n}\in[0,\bar{n}_2]}u_{2,s}([w_2\tilde{h}_2\tilde{\varepsilon}]\tilde{n},\bar{n}_2-\tilde{n})$$

The outside option to marriage is to remain single for the second period and receive utility $u_{2,s}(c_{2,s},\ell_{2,s})$ where

$$n_{2,s}=\arg\max_{n\in[0,\bar{n}_2]}u_{2,s}([w_2h_2\varepsilon]n,\bar{n}_2-n)$$

$$c_{2,s}=(w_2h_2\varepsilon)n_{2,s}$$

$$\ell_{2,s}=\bar{n}_2-n_{2,s}$$

Since marriage occurs only when there is a solution to Nash bargaining problem defined above, the second period value conditional on having a potential spouse can be written as

$$V_m(h_2,\varepsilon,\tilde{h}_2,\tilde{\varepsilon},\eta)=\begin{cases} u_{2,m}(c_{2,m}(h_2,\varepsilon,\tilde{h}_2,\tilde{\varepsilon},\eta), & \text{if } \{c_{2,m}(h_2,\varepsilon,\tilde{h}_2,\tilde{\varepsilon},\eta), \\ \qquad \ell_{2,m}(h_2,\varepsilon,\tilde{h}_2,\tilde{\varepsilon},\eta)) & \qquad \ell_{2,m}(h_2,\varepsilon,\tilde{h}_2,\tilde{\varepsilon},\eta)\}\neq\emptyset \\ u_{2,s}(c_{2,s},\ell_{2,s}) & \text{otherwise}\end{cases}$$

Given the above value, at age 16, conditional on a wage shock and a distribution of human capital over mass j, an agent in mass i solves:

$$\max_{n_1,e_1}u_1(c_1,\ell_1)+\beta\left[(1-\theta)u_2(c_{2,s},\ell_{2,s})+\theta E_{\tilde{\varepsilon},\tilde{h}_2,\eta}[V_m(h_2,\varepsilon,\tilde{h}_2,\tilde{\varepsilon},\eta)]\right]$$

subject to

$$c_1+\gamma e_1=(w_1h_1\varepsilon)n_1$$

$$\ell_1 = \bar{n}_1 - n_1 - e_1$$

$$n_1, e_1, \ell_1 \in [0, \bar{n}_1]$$

$$c_1 \geq 0$$

$$h_2 = h_1 + \phi e_1 + \kappa n_1$$

The wage shocks in period one are i.i.d. and log-normally distributed with zero log-mean and some log-variance, σ_ε.

2.2 Married Utility

Before examining how marriage functions in this model, it is important to briefly consider the form of utility in marriage. While utility is not transferable within the marriage, the budget constraint is shared and shifting consumption acts in a way to transfer utility from one spouse to another. However, because the utility functions of the spouses remain separate, there is no sense of economies of scale within the marriage. This may seem particularly unappealing if one takes the leisure term in the utility function, in part, as some representation of home production. However, the goal in specifying the model in this manner is to maintain individual incentives in the marriage that will drive behavior earlier in life.

Additionally, going forward, the married utility function is generally assumed to be identical to the single utility function with the exception of the η term, though this is only required where noted. That the η term enters identically into both spouses utility functions is also a strong assumption. However, expanding the married state space to include another term creates issues of tractability and identification.

2.3 The Marriage Decision

It is straightforward to show that without the marital utility term, marriages do not form, or rather, agents are at best indifferent between marrying and not, regardless of the division rule. Suppose there is no additional utility from marriage ($u_{2,m} \equiv u_{2,s}$), utility is strictly increasing in consumption and leisure, and that some marriage is at least as good as being single for both agents. Consider the case where one agent consumes less than her share of income contributed to the marriage. Since this level of consumption and leisure was available outside the marriage, by the weak axiom of revealed preference, she must be indifferent between this allocation and her optimal single allocation. But holding leisure constant and increasing her consumption from this point was also possible when single and necessarily increases her utility. Therefore, happily married agents must each consume their respective shares of income. Given this, applying WARP again, both agents must find their marriage consumption and leisure equivalent to their optima when single.

This line of logic leads to a simple rule for utility functions of a certain form.

Claim 1. *Given utility that is quasi-linear in η, the bargaining set is non-empty (i.e., there are gains from marriage) if and only if $\eta \geq 0$.*

Proof. It follows from the argument above that a necessary condition for marriage is $\eta \geq 0$. This condition is also sufficient. If both spouses consume and work as they did outside of marriage, their respective surpluses are exactly equal to η and thus positive whenever η is. □

Similar rules can be established for utility functions of different forms. Generally, if utility is increasing in η, a cutoff value $\bar{\eta}$ exists where $\bar{\eta}$ solves $u_m(c^*_{2,s}, \ell^*_{2,s}, \bar{\eta}) = u_s(c^*_{2,s}, \ell^*_{2,s})$.

2.4 The Nash Bargaining Solution

In order for a unique solution to the Nash bargaining problem to exist, the bargaining set must be convex.

Claim 2. *The bargaining set is convex if $u(c, \ell, \eta)$ is concave in c, ℓ.*

Proof. Since u is concave, we have

$$\lambda u(c, \ell, \eta) + (1 - \lambda) u(c', \ell', \eta) \leq u(\lambda c + (1 - \lambda) c', \lambda \ell + (1 - \lambda) \ell', \eta)$$

for both agents. Since the choice set is convex by the nature of the problem, this allocation is feasible. □

Nash's theory of bargaining assumes a symmetric outcome given two symmetric agents. Thus, there are cases when bargaining in the marriage does not yield an outcome different from that of single individuals. Consider two wage rates ϖ_i and ϖ_j, where in the context of this model $\varpi_i = w_2 h_{2,i} \varepsilon_i$.

Claim 3. *If utility is strictly quasi-concave in c, ℓ, quasi-linear in η, and either $\eta = 0$ or $\varpi_i = \varpi_j$, then the Nash bargaining allocation is identical to that chosen when the individuals maximize separately (i.e., are single).*

Proof. First, observe that the utility levels are unchanged. An argument for the first case, $\eta = 0$, is given in the previous section. For the case of equal wages, observe that the bargaining problem is entirely symmetric. Nash's symmetry axiom implies that consumption and labor must be equal across both parties. Thus, each agent consumes her own income. By the same argument used in the first case, the utility level is no different than the individual maximum.

Since the utility function is quasiconcave in the first two arguments, the Hicksian demand is single-valued and allocations are identical. □

Given two unequal wages and $\eta = 0$, the solution is symmetric and no different than the single-individual solution. It might seem, then, that moving η away from zero, which effects each agent symmetrically, would have no effect on the Nash bargaining solution and that marriage is therefore a rather boring affair in the context of this model. However, as η is increased when wages are unequal, the resulting bargaining set is not symmetric. More importantly, there is no symmetric set containing the new bargaining set with the original optimal allocation on its boundary, and so the optimum must change. This idea is formalized below.

Claim 4. *For strictly concave utility of the form $u_m \equiv u_s + \eta$, and $\eta > 0$, $\varpi_i \neq \varpi_j$, the Nash bargaining allocation is not equal to the allocations chosen by the single individuals.*

Proof. Suppose the opposite: $c_s^* = c_m^*$ and $n_s^* = n_m^*$. This implies that $u_{m,i}^* = d_i + \eta$. Define $\hat{u}_i = \frac{1}{\eta}(u_{m,i} - d_i)$. By Nash's symmetric normalization argument, this is the solution if and only if $\hat{u}_i + \hat{u}_j \leq 2$, $\forall$ $\{\hat{u}_i, \hat{u}_j \mid \hat{u}_i, \hat{u}_j \text{ feasible}\}$.

This implies the following inequality:

$$u_s(\pi[\varpi_i n_i + \varpi_j n_j], 1 - n_i) + u_s([1-\pi][\varpi_i n_i + \varpi_j n_j], 1 - n_j) \leq d_i + d_j$$

for all $\pi, n_i, n_j \in [0, 1]$.

Without loss of generality, consider the case where $\varpi_i > \varpi_j$. Starting from the single optima (d_i and d_j), increase n_i to $n^*_{i,s} + \xi$, where ξ is small, and use the additional income to increase the consumption of agent j. Since by the concavity of the utility function, $MU_{c,i} = MU_{\ell,i} < MU_{c,j} = MU_{\ell,j}$ at the individual maxima, this must have increased the total utility within the match. $\perp$ $\square$

The effect of a higher wage on the surplus gained from marriage is complex. As can be gleaned from the above proof, the higher-wage individual may work more and consume less in marriage, although this is not always the case. There are two separate effects at work. First, a higher wage increases the value of being single and improves one's bargaining position. Second, a higher wage increases the incentive to specialize in labor. The relative sizes of these effects depend on the particular match and on the specification and parameterization of the utility functions. To help elucidate this dimension of the problem, the outcomes of bargaining in the estimated equilibrium are shown in the results section below.

3 Solving for Equilibrium and Estimation

Solving the above problem for mass i agents gives optimal choices for schooling and labor during the first period, conditional on a wage shock and a distribution of human capital for mass j. Using the law of motion for human capital and the distribution of period one wage shocks gives a distribution of second period human capital for mass i. From this, a new distribution of h_2 for mass j can be calculated in the same way. To find the equilibrium distribution of human capital (and labor, education, and marriage decisions), this process is repeated until convergence of the distributions.

While there is no guarantee that this fixed point is symmetric across genders (and for some parameterizations, it is not), non-symmetric solutions are ignored. Furthermore, multiple equilibria are tested for only to the extent that a unique solution is verified by starting the problem at multiple initial conditions. The theory of the equilibrium distributions is beyond the purview of this paper.

The utility functions are given by

$$u_1(c, \ell) = c^{\rho_1} \ell^{1-\rho_1},$$

$$u_{2,s}(c, \ell) = c^{\rho_2} \ell^{1-\rho_2},$$

and

$$u_{2,m}(c, \ell, \eta) = c^{\rho_2} \ell^{1-\rho_2} + \eta.$$

These utility functions are strictly increasing, concave (strictly in c, ℓ), quasiconcave in c, ℓ, and of course quasi-linear in η, so that the above claims apply.

The Nash bargaining problem does not have a closed form solution for the given utility function and so is solved numerically. To speed up computation, the problem is solved on a grid of wages and marital utilities once for a given set of parameters. The associated integral for the expected second period utility (which must be updated for each iteration on the human capital distributions) is calculated using linear interpolation.

Data and Parameter Selection

The age break between periods (28) is the median age for first marriage for men in the United States. The discount rate β is also taken from outside the model to be $0.96^{28-16} = 0.613$. Similarly, $\bar{n}_2$ is normalized to 1, and $\bar{n}_1$ is set to $\frac{28-16}{65-28} = 0.2449$. Initial human capital, h_1, is also normalized to 1.

The cost of education is approximated using data from the Integrated Postsecondary Education Data System (IPEDS). The average net cost of tuition in the U.S. in 2001, weighted by enrollment, is deflated by 0.561 (the approximate change in real tuition costs over the previous twenty years) and converted to 2011 dollars. To calculate the model cost of schooling, γ, it is assumed that the observed rate is for forty hours per week for thirty weeks per year.

The remaining parameters are either estimated or calculated directly using data from the NLSY '79. The annual/bi-annual survey follows men and women of a common cohort over a long period of their lives, beginning as they reach working and college age (in 1979) and extending through marriage and beyond (up to 2010). The dataset includes individuals' labor force and education decisions, as well as their wages and marital status. The oldest respondent in the sample is 58 and any observations before age 16 were dropped. Anyone married prior to age 16 was also dropped (only 12 observations). The final sample contains 12,665 individuals with an average of 21.5 years of non-missing data per respondent. Table (1) lists several summary statistics for the sample used here.

Table 1: Summary Statistics (Individual Level)

Variable	Mean	Std. Dev.	Min	Max	N
Age at first interview	18.17	1.94	16	22	12665
Female	0.4948	0.5000	0	1	12665
Observed years of school enrollment	2.548	2.770	0	17	12665
Hours per week (unconditional)	25.79	13.18	0	82.77	12661
Hours per week (full-time)	44.29	6.28	35.08	111.84	10916
Average annual wages (unconditional)	26,258	19,670	0	191,698	12290
Average annual wages (full-time)	37,178	24,317	1,950	322,183	10809
Observed years	21.52	8.67	1	29	12665

During the second period, giving the chosen utility function, single individuals work at constant rate ρ_2. Therefore, the mean hours worked by never-married individuals aged 28-65 is used for this parameter. Because the model extends to age 65 and the NLSY does not extend beyond age 58, it is assumed that hours are constant over the remaining 7 years (since wage growth is usually slowest during this period of life).

The probability of not receiving a possible marriage arrival, θ, is generally not identified separately from the distribution of the marital utility, η, since there exists a cutoff value below which marriage never occurs. For the purposes of this model, it is not important to distinguish between not receiving an offer and receiving a poor offer. Thus, θ is set to 0, and it is assumed any never-married individual simply received a poor draw.

The cutoff rule for marriage allows the marriage rate to identify one parameter in the distribution of η. The ever-married rate is used here under the assumption that any marriage corresponds to the arrival of an adequate match. (Divorce is not planned in this framework). This statistic is used to find μ_η given σ_η.

The rental rates for human capital are calculated directly from the data. For the first period, w_1 is chosen so that it is equal to the mean wage for ages 16-27. The wage for the second period is not separately identified from κ, ϕ, and ρ_1. Therefore, this value is chosen to be the mean wage for ages 28-65 for unmarried individuals who did not attend school and worked for less than 100 hours during ages 16-27 (approximately $6 * w_1$). The variance of the wage shock is calculated from the observed variance of wages for those aged 16-27.

A summary of the parameters chosen from the data is given in Table (2). The remaining parameters in the model (ρ_1, ϕ, κ, and σ_η) are estimated using simulated method of moments. The data

Table 2: Parameters Calculated Directly

Parameter	**Estimate**
h_1	1
w_1	3.7032×10^6
w_2	7.4311×10^6
γ	1.9441×10^6
β	0.6130
ρ_2	0.2006
θ	1
$\bar{n}_1$	0.2449
$\bar{n}_2$	1
σ_ε	0.2727
Marriage rate	0.8207

moments matched are mean labor hours for ages 16-27, mean married labor hours for ages 28-65, mean wages for ages 28-65, married wage variance for ages 28-65, and schooling for ages 16-27. The final moment is observed as an annual binary enrollment variable. This is converted to hours assuming enrollment is equivalent to forty hours per week for thirty weeks per year.

4 Results

Table (3) lists estimates and standard errors for the parameters estimated by SMM. The return to schooling in the human capital production function is estimated to be approximately ten times larger than that of labor. Relative to the second period, ρ_1 is approximately half as large. There is an incentive to work more in the first period, both to accumulate human capital and to finance schooling. However, in the data, labor hours are on average lower during the first period of life

Table 3: Parameter Estimates and Standard Errors

Parameter	**Estimate/SE**
ρ_1	0.1137
	(4.9587×10^{-25})
κ	0.3974
	(3.1863×10^{-26})
ϕ	3.6784
	(1.8878×10^{-22})
σ_η	3.23725
	(3.8716×10^{-28})
μ_η	2.9718

Table 4: Matched Moments

Moment	**Data**	**Model**
Mean Hours/Week, Ages 16-27	21.92	22.91
Total Semesters in School, Ages 16-27	7.99	8.12
Mean Hourly Wage, Ages 28-65	24.91	23.78
Mean Hours/Week, Ages 28-65, Married	34.69	33.37
SD of Hours/Week, Ages 28-65, Married	0.2308	0.0121

(usually offset by schooling). The lower ρ_1 increases the value of leisure to match this data fact. Finally, the standard deviation of the marital utility shocks is approximately 20 percent of the average individual surplus observed in marriage. Note that since μ_η is a function of σ_η, a standard error is not calculated for it.

Table (4) lists the data moments matched and the corresponding values produced by the model. The model is able to match all fours means well. However, the observed second period labor variance is much higher than the model can produce. In general, the model has trouble matching the spread of variables observed in the data. Because all the heterogeneity in the model derives from the initial wage shocks, the model's ability to match variance across multiple dimensions is limited. Figure (1) illustrates this fact. The model's distribution of labor decisions is hump-shaped and centered on the same mean but is much narrower than the empirical spread.

The distribution of education decisions is shown in Figure (2). The model produces a longer tail and puts most of the mass at zero. This can be explained by the linearity of both the returns to education and the cost of schooling. The returns to schooling are likely decreasing quickly past a certain point (beyond a full load per semester or past the Ph.D. level, for instance), but the model does not inflict such a drop-off. For most, schooling during ages 16-18 is free or very low cost. However, the model imposes the same cost for these years of schooling as it does for college years and beyond. This causes poor-wage-draw individuals to choose zero schooling. More complex human capital production and schooling cost functions would likely serve to match the data better here. Figures (3) and (4) show the labor and schooling decisions as policy functions.

Figure (5) shows the individual surplus from marriage for the range of wages seen in the estimated equilibrium, for several levels of marital utility. When one's own wage is low, the surplus gained is very high since the utility function rises quickly at low levels. With the exception of the own wage-lower bound, surplus is increasing in spousal wage. If marrying down in wage, a higher-wage spouse means less consumption transferred away; if marrying up in wage, it means more

Figure 1

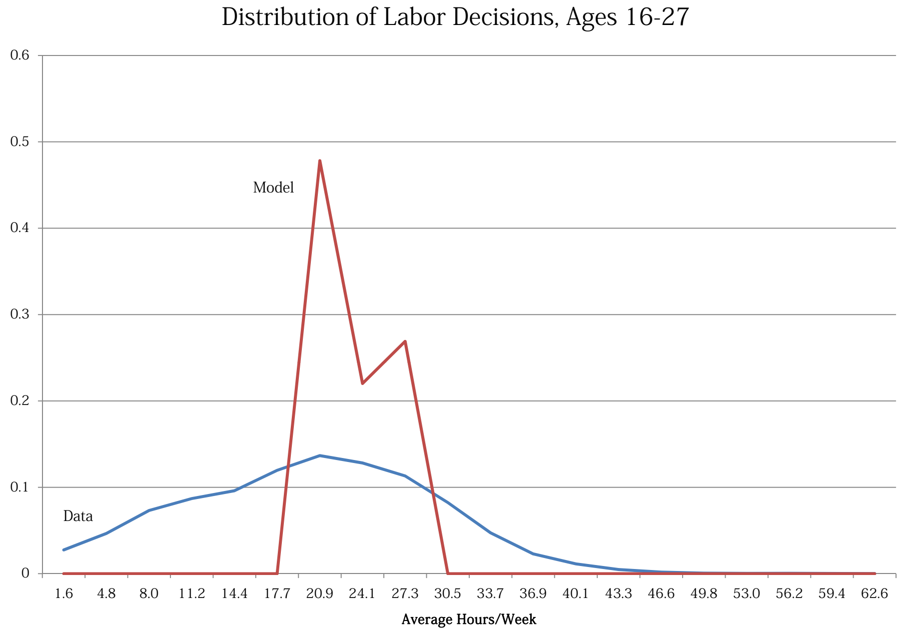


Figure 2

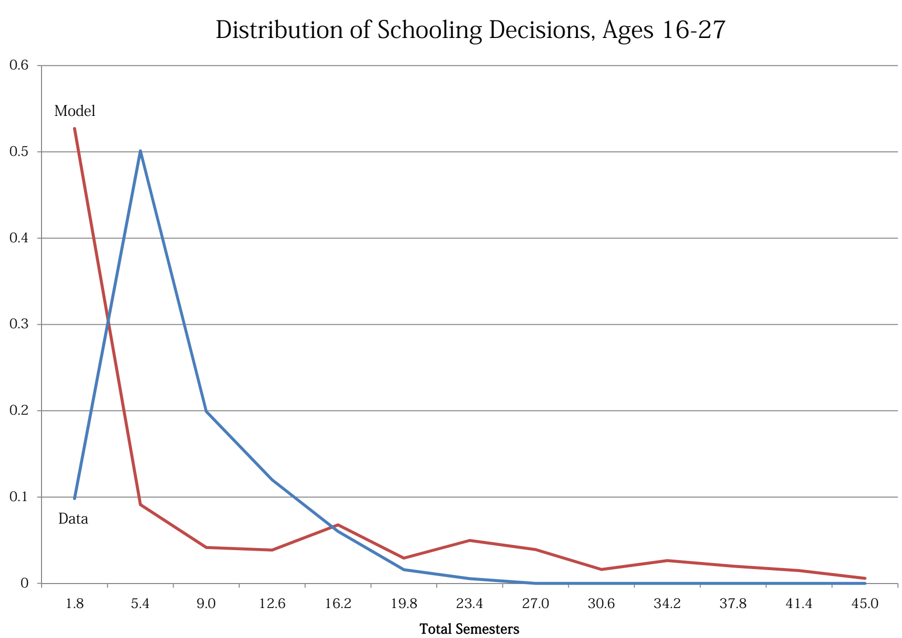


Figure 3

Figure 4

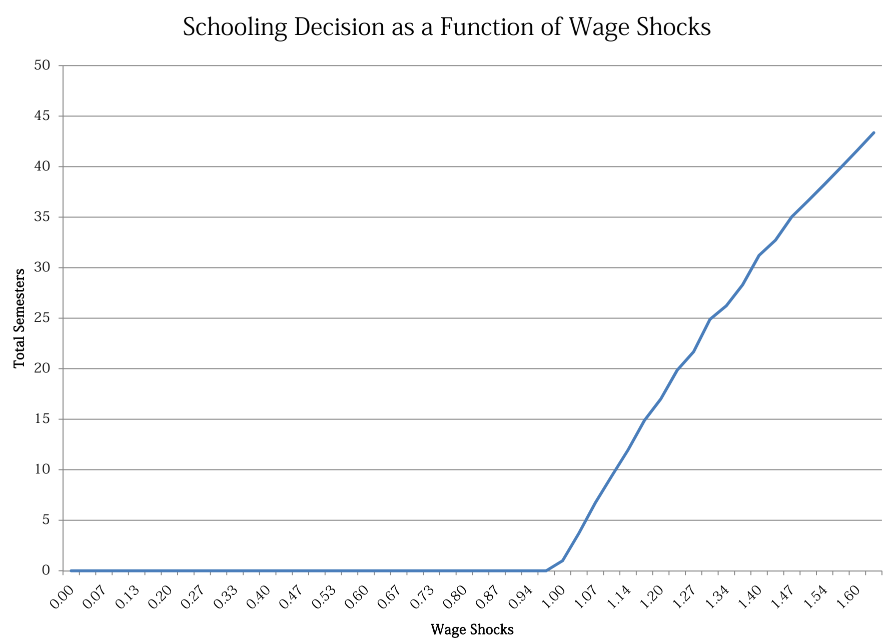
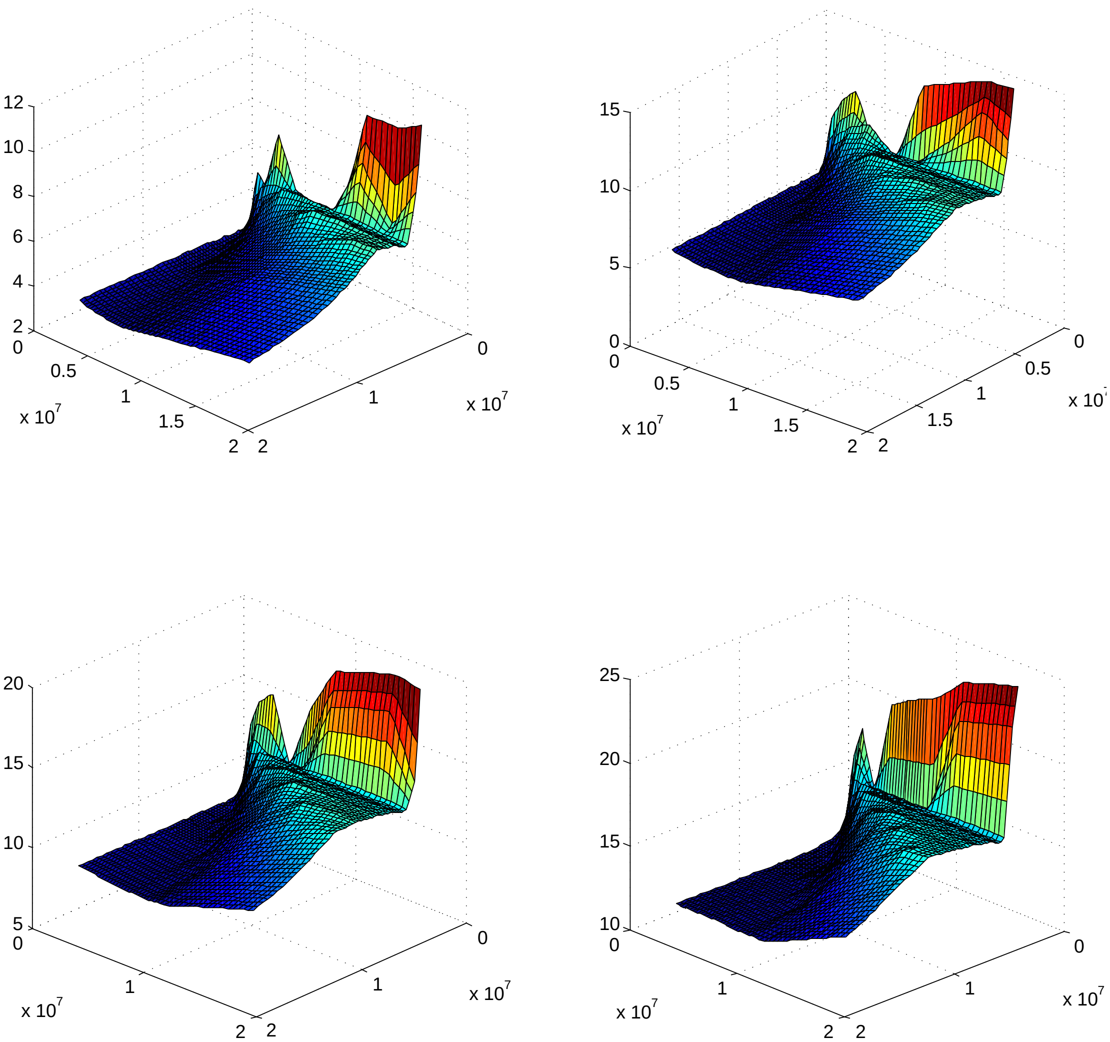


Figure 5: Surplus Plots



Note: Marital utility increasing left to right, own wage on right axis, spouse wage on left.

consumption received.

The surplus is generally decreasing in own wage. This demonstrates the strength of the specialization effect: the spouse with the higher wage potential tends to work more because this is the most efficient manner of generating household income. There is a region where surplus is increasing in own wage, but this cannot be attributed to the bargaining positions as it persists even when bargaining positions are set to zero (as can be seen in the following section).

Finally, the distribution of surplus becomes more extreme as marital utility increases. The marital utility term acts to dilute the bargaining positions and does so in an increasing fashion. At higher levels, the bargaining positions matter less and the split becomes more even, further reducing the surplus of the higher wage individual and increasing that of the low wage spouse. The extreme case where η goes to infinity is equivalent to setting the bargaining positions both to zero. This exercise is done below.

5 Counterfactuals

For the following experiments, the rule for splitting the surplus within the marriage is changed. Throughout, the marriage acceptance rule remains the same. Since, as is shown above, there is a constant cutoff rule regardless of the split, there is no reason to consider changing this dimension. Furthermore, the participation constraint in marriage is always respected (no negative surpluses are chosen). For each, new steady state distributions are calculated so that the results below represent alternative equilibrium outcomes.

The first approach taken to quantifying the impact of bargaining is to set the bargaining positions to zero for both parties. The objective function in the marriage is then the product of the two utilities, irrespective of the individuals' outside options. When the positions are zero, human capital in the marriage becomes a public good will be underproduced. In this sense, the Nash bargaining serves to maintain returns to one's own human capital and reduce freeriding.

The second approach taken assigns the full surplus from marriage to one of the two partners with equal chance. While the first experiment eliminated the bargaining positions, it also increased the freeriding. This rule does not increase the incentive to freeride but does remove the bargaining incentives. The difference between this and the baseline should approximate the over-accumulation

Table 5: Counterfactual Moments

Moment	Baseline	Max Product	Random Surplus
Mean Hours/Week, Ages 16-27	22.91	20.54	21.87
Total Semesters in School, Ages 16-27	8.12	1.78	3.93
Mean Hourly Wage, Ages 28-65	23.78	22.75	23.11
Mean Hours/Week, Ages 28-65, Married	33.37	32.26	26.14
SD of Hours/Week, Ages 28-65, Married	0.0121	0.2603	0.0464

of human capital due to bargaining incentives.

Table (5) lists the five matched moments for the baseline and the two counterfactuals. The first case has the greatest effect on human capital accumulation since it is the combined impact of removing bargaining incentives and allowing greater freeriding. The second case moderates this effect for the reasons described above.

Figures (6) and (7) shows where in the distribution of wages shocks these shifts are happening. The first experiment reduces human capital across most of the shock distribution with the exception of the far right tail (high wages) where human capital is actually accumulated at a higher rate than the baseline. The second experiment reduces accumulation across the entire distribution. Figures (8) and (9) plot the (expected) surplus for each counterfactual at equilibrium wages.

6 Conclusion

The above results imply that the incentive to maintain a better bargaining position in marriage is high – almost 55 hours of labor annually and over 2 years of schooling during the first 12 years of adulthood. These levels may seem high based on common wisdom, but they suggest that such incentives exist and may be sizable. Evidence that demonstrates Nash bargaining solutions correspond to observed household allocations would further support these findings. In addition, a model that allows for multiple opportunities to marry and that incorporates divorce (see Appendix) would help to more accurately estimate the effect observed here.

Figure 6

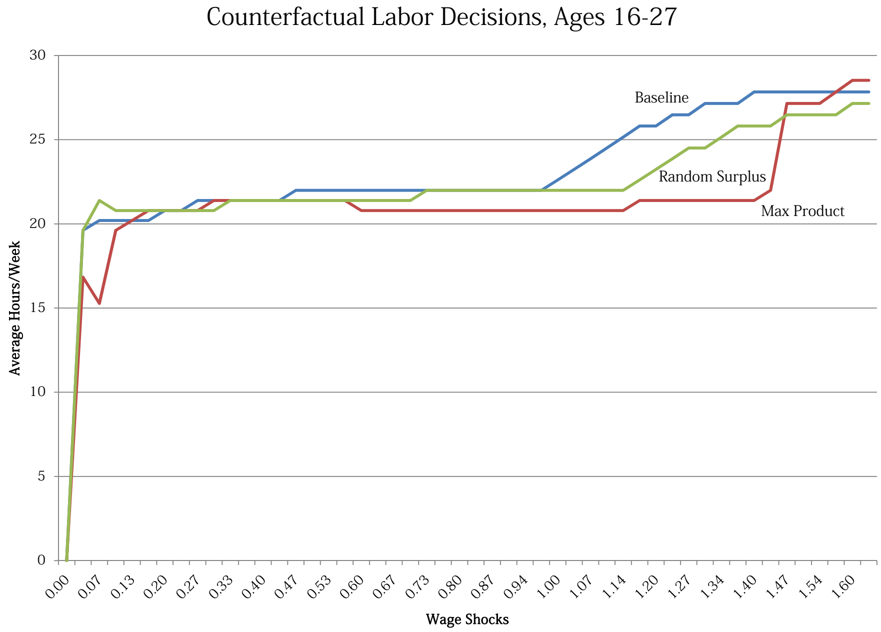
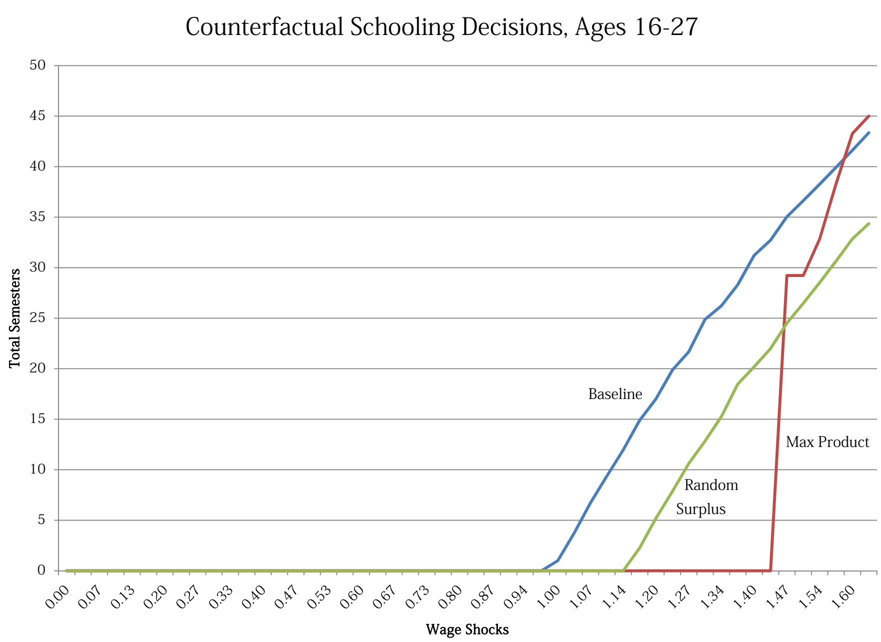


Figure 7



Note: Own wage on right axis, spouse wage on left.

Figure 8: Max Product Surplus Plot

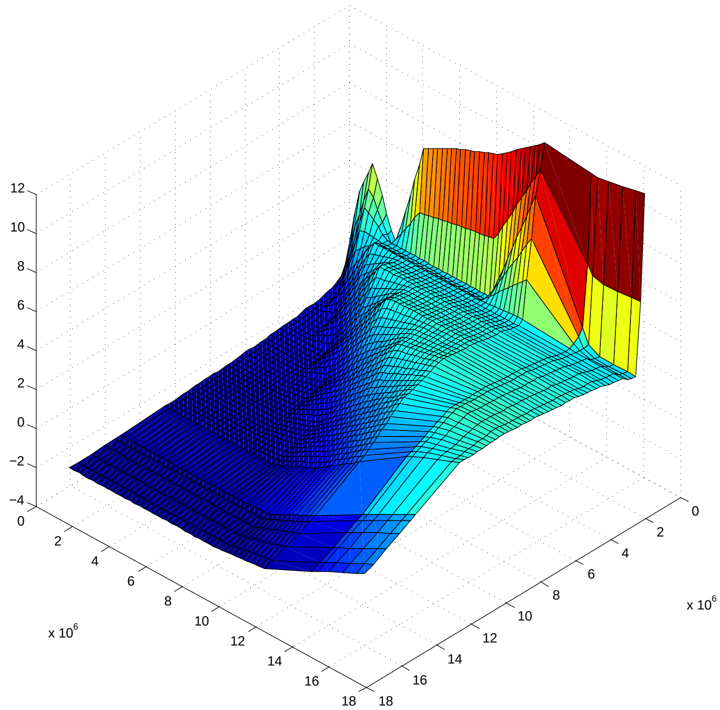
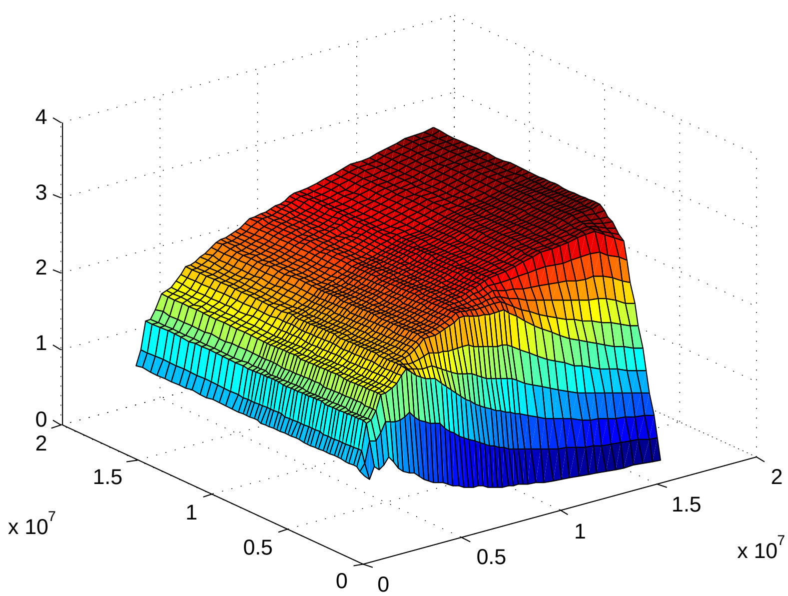


Figure 9: Random Surplus Plot



Appendix: The T Period Model

The T-period version of the model is identical to the version above, but the agents now make premarital decisions over the course of several periods and may have multiple marriage opportunities over the lifetime. An agent who is single in period $t < T$ now solves

$$V_{t,s}(h_t, \varepsilon) = \max_{n_t, e_t} u_{t,s}(c_t, \ell_t) + \beta \left[(1-\theta) V_{t+1,s}(h_{t+1}, \varepsilon) + \theta E_{\tilde{\varepsilon}, \tilde{h}_{t+1}, \eta} [V_{t+1,m}(h_{t+1}, \varepsilon, \tilde{h}_{t+1}, \tilde{\varepsilon})] \right]$$

subject to

$$c_t + \gamma e_t = (w_t h_t + \varepsilon) n_t$$

$$\ell_t = \bar{n}_t - n_t - e_t$$

$$n_t, e_t, \ell_t \in [0, \bar{n}_t]$$

$$c_t \geq 0$$

$$h_{t+1} = h_t + e_t + \kappa n_t$$

$$V_{t,m}(h_t, \varepsilon, \tilde{h}_t, \tilde{\varepsilon}, \eta) = \begin{cases} u_{t,m}(c_{t,m}(h_t, \varepsilon, \tilde{h}_t, \tilde{\varepsilon}, \eta), \ell_{t,m}(h_t, \varepsilon, \tilde{h}_t, \tilde{\varepsilon}, \eta), \eta) & \text{if } \{c_{t,m}(h_t, \varepsilon, \tilde{h}_t, \tilde{\varepsilon}, \eta), \\ \quad + V_{t+1,m}(h_{t+1}, \varepsilon_{t+1}, \tilde{h}_{t+1}, \tilde{\varepsilon}_{t+1}, \eta) & \quad \ell_{t,m}(h_t, \varepsilon_t, \tilde{h}_t, \tilde{\varepsilon}_t, \eta)\} \neq \emptyset \\ V_{t,s}(h_t, \varepsilon_t) & \text{otherwise} \end{cases}$$

where

$$\begin{aligned} &\{c_{t,m}(h_t, \varepsilon, \tilde{h}_t, \tilde{\varepsilon}, \eta), \bar{n}_t - \ell_{t,m}(h_t, \varepsilon, \tilde{h}_t, \tilde{\varepsilon}, \eta), \tilde{n}_{t,m}\} = \\ &\qquad \arg \max_{c \geq 0, \{n, \tilde{n}\} \in [0, \bar{n}_t]^2} \Big\{ \big(u_{t,m}(c, \bar{n}_t - n, \eta) + V_{t+1,m}(h_{t+1}, \varepsilon, \tilde{h}_{t+1}, \tilde{\varepsilon}, \eta) - V_{t,s}(h_t, \varepsilon) \big) * \\ &\qquad\quad \big(u_{t,m}([w_t h_t + \varepsilon] n + [w_2 \tilde{h}_t + \tilde{\varepsilon}] \tilde{n} - c, \bar{n}_t - \tilde{n}, \eta) + \tilde{V}_{t+1,m}(\tilde{h}_{t+1}, \tilde{\varepsilon}, h_{t+1}, \varepsilon, \eta) \\ &\qquad\qquad - \tilde{V}_{t,s}(\tilde{h}_t, \tilde{\varepsilon}) \big) \Big\} \end{aligned}$$

subject to

$$u_{t,m}(c, \bar{n}_t - n, \eta) + V_{t+1,m}(h_{t+1}, \varepsilon, \tilde{h}_{t+1}, \tilde{\varepsilon}, \eta) - V_{t,s}(h_t, \varepsilon) \geq 0$$

$$u_{t,m}([w_t h_t + \varepsilon] n + [w_2 \tilde{h}_t + \tilde{\varepsilon}] \tilde{n} - c, \bar{n}_t - \tilde{n}, \eta) + \tilde{V}_{t+1,m}(\tilde{h}_{t+1}, \tilde{\varepsilon}, h_{t+1}, \varepsilon, \eta) - \tilde{V}_{t,s}(\tilde{h}_t, \tilde{\varepsilon}) \geq 0$$

The above value functions for mass i also carry with them all future distributions of human capital for mass j (hence why $V(\cdot) \neq \tilde{V}(\cdot)$), but these terms are suppressed to save space.

The expanded model allows marriage to occur at one of several ages and for human capital accumulation to be spread over time (this changes marriage incentives as the distribution of potential spouses shifts over the lifetime). While divorce is not specified in the model, it is easily added as an exogenous discount to the value of marriage.

In this context, the dynamic Nash bargaining solution is not necessarily dynamically consistent [Haurie, 1976]. That is, one or both of the partners may have incentive to deviate if he or she is fully selfish or not otherwise compensated. An alternate approach is to have the spouses bargain over a plan for the entire marriage. Since the agents may prefer constant levels of leisure over the lifecycle, the choice space would be a τ^2-dimensional hypercube where τ is the number of periods remaining before death. Even if the bargaining is simplified to a single married period of varying length, the problem would expand the number of computations by a factor of $T-1$ compared to the two-period model.

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