Accounting for Labor Force Participation of Married Women: The Case of the U.S. since 1959.*

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We quantitatively investigate the role of changes in several aspects of the joint earnings distribution of married couples and the decline in prices of home appliances in accounting for the dramatic rise in labor force participation of married females since 1959. We use a model with heterogeneous agents, which allows for the investigation of cross-sectional implications of the factors examined. The key finding is that changes in the distribution of potential wages can account for 88% of the observed increase in the labor supply of married females and in a manner consistent with several cross-sectional properties of the female labor supply that we document using the U.S. Census data. This result is due mainly to the closing of the gender wage differential, as opposed to changes in matching patterns or within gender inequality. Further, the decline in prices of home appliances has an effect in the right direction, but this effect is quantitatively small, accounting for 5% of the rise in female labor force participation.

Keywords: labor force participation, home production, gender wage gap
JEL Codes: J2, J3, E0

I. Introduction

Female labor force participation (LFP) in the U.S. has been on a steady rise over the last century. It increased from 18% in 1890 to 60% in 1998[1]. This change is due mostly to married women entering the workforce. Indeed, while the participation of single women increased by 80% during this period, the participation of married females increased by more than a factor of 13. In the period 1959-1999 alone, LFP of married females has more than doubled. Notably, this increase has occurred for women by all groups of husband's income, and even more so for women whose husbands are at the top of the wage distribution.

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[1]See Costa (2000) for the comprehensive documentation of historical trends in female labor force participation rates in the U.S. and other OECD countries.

A number of explanations for this phenomenon have been proposed.[2] Most commonly cited among the economic forces are the closing of the gender wage gap and the *revolution* in home production. The latter refers to the widespread diffusion of electrical appliances, such as washing machines, dishwashers and vacuum cleaners. Among non-economic forces, the most frequently mentioned are changes in social norms and women's role in a society. Still, there is little consensus regarding the main forces behind the rise in LFP of married women. For example, both Jones et al. (2003) and Greenwood et al. (2003) investigate the relative importance of the falling gender wage gap and the revolution in household production reaching the opposite conclusions.

Jones et al. (2003) find that a small reduction in the gender wage differential, modeled as a discrimination tax on female income, can account for the entire observed increase in the labor supply of married females during 1950-2000. The decline in the prices of home appliances is found to be much less important quantitatively. By contrast, in Greenwood et al. (2003), the simulated time path of married female LFP that results when the time series of declining prices of home appliances is fed into their benchmark model exhibits an even greater increase than its counterpart in the data, while the impact of the falling gender wage gap in their model is small.

One objective of this paper is to extend the test of these competing explanations to cross-sectional features of the rise in LFP of married females as well as the pattern of relative leisure of husbands and wives. Using the U.S. Census data providing relevant information for 1959, 1969, ..., 1999, we examine female LFP for groups of couples differentiated by male earinings. We document that although female participation increased for all groups, the increase was greater for females married to men at the top of the income distribution. Utilizing time-use surveys, Aguiar and Hurst (2006) document trends in time allocation for the U.S. population. They find that non-retired married men of age 21-65 increased their leisure[3] by 12.5% while married females experienced a 7.7% rise in leisure between 1965 and 2000, relative leisure of men to that of women increasing by 4%. Since the mechanism explored in this paper provides stark predictions with respect to leisure, this information can be used to help evaluate the relative importance of the forces behind changes in female LFP.

To do so, we construct a model of heterogenous agents in which married couples jointly decide on their time allocation between market work, home work, and leisure. Individual heterogeneity with respect to their earnings ability allows us to compare the implication of the proposed explanations for female participation by interval of the husband's real income against data.

In addition, we quantitatively investigate the role of changes in the entire joint wage distribution of husbands and wives. The idea that other aspects of the joint wage distribution may be important for households' time allocation decision is relatively novel. Mulligan and Rubinstein (2002) present a reduced-form model of household specialization in which, for some parameter values, the female labor supply increases even more in response to increasing income inequality than in response to closing of the gender wage gap, thus suggesting that changes in within-gender inequality may represent a quantitatively important force behind the rise in female LFP. Changes in the correlation of husbands' and wives' incomes, possibly resulting from changes in the assortativeness of matching, may also impact the aggregate female

[2] See Goldin (1990) for an extensive review.

[3] To be consistent with our measure of leisure, we take out sleeping/eating/grooming time (71.64 and 71.84 per week for 1965 and 2003 respectively) from leisure Measure 4 in Table 8 of Aguiar and Hurst (2006).

labor supply.

Our model draws on several desired features from both, Jones et al. (2003) and Greenwood et al. (2003). Since most of the change in married female labor supply occurred at the *extensive* rather than the *intensive* margin, that is, due to women entering the workforce as opposed to working longer hours, we choose to focus on the participation decision. We assume, as in Greenwood et al. (2003), that the market hours of work are fixed, although at different levels for men and women in order to be consistent with the data. Both partners can work at home. We deviate from Greenwood et al. (2003) that assumes perfectly assortative matching and models the cost of household appliances in terms of hours of work at the mean skill level. Instead, we use a more standard budget constraint. We also assume that the wages of husbands and wives are jointly log-normally distributed. Like much of the labor literature, we face the problem of selectivity bias, as the wages of non-workers are not observed. To overcome this problem, we use a censored regression model in conjunction with our calibrated model to estimate the parameters of the wage distribution.

Simplified Mechanism

It is instructive to illustrate how different aspects of the wage distribution affect LFP in a simplified version of our main framework. Suppose that a wife joins the workforce if her income relative to her husband's income is sufficiently large.[4] More formally, indexing female income by f and male income by m, suppose a wife participates in the workforce if

$$w_f \geq a w_m,$$

or $\log(w_f) - \log(w_m) \geq \log(a)$. We assume that a couple's market wages are drawn from a bivariate log-normal distribution, $\left(w_m^i, w_f^i\right) \sim LN(\mathbf{m}, \mathbf{S})$, the arguments denoting the mean vector and the covariance matrix. Let $X \equiv \log(w_m)$ and $Y \equiv \log(w_f)$ denote the underlying normal random variables, so that $(X, Y) \sim LN(\boldsymbol{\mu}, \boldsymbol{\Sigma})$.[5] Then $Y - X \sim N\left(\mu_Y - \mu_X,\ \sigma_Y^2 + \sigma_X^2 - 2\sigma_{XY}\right)$ and the participation rate of wives, or equivalently, the fraction of two-earner couples among all couples, is given by

$$P(2E) = P(Y - X \geq \log(a)) = \Phi\left(\frac{\mu_Y - \mu_X - \log(a)}{\sqrt{\sigma_Y^2 + \sigma_X^2 - 2\sigma_{XY}}}\right) = \Phi(Z),$$

where Φ is the cumulative standard normal distribution. Expressing Z in terms of the gender wage gap, $GWG = m_2/m_1$, within-gender inequality measured by the coefficient of variation, $CV(w_i) = \sqrt{s_{ii}}/m_i$, and assortativeness of matching measured by correlation, $\rho(w_m, w_f) = s_{12}/\sqrt{s_{11}s_{22}}$, gives[6]

$$Z = \frac{\log(GWG) + \frac{1}{2}\log\left(1 + CV(w_m)^2\right) - \frac{1}{2}\log\left(1 + CV(w_f)^2\right) - \log(a)}{\sqrt{\log\left(1 + CV(w_f)^2\right) + \log\left(1 + CV(w_m)^2\right) - 2\log\left(1 + \rho(w_m, w_f)\, CV(w_m)\, CV(w_f)\right)}}.$$

Clearly, an increase in GWG, that is, closing of the gender wage gap raises the fraction of two-earner

[4] Our model with no home production or Cobb-Douglas home production function yields such (linear) decision rule.

[5] There is a one-to-one mapping from (m, S) to (μ, Σ).

[6] All the derivations are reported in the appendix.

couples. The effect of $\rho(w_m, w_f)$ depends on whether most of the women participate or not. If most women stay at home ($Z < 0$), then higher $\rho(w_m, w_f)$ further dampens female LFP. The effect of within-gender inequality is also ambiguous. To illustrate, consider the special case with $CV(w_f) = CV(w_m)$. In this case, $Z = \frac{\log(GWG) - \log(a)}{\sqrt{2\log(1+CV^2)/(1+\rho \cdot CV^2)}}$, and increasing inequality draws females into the labor force only if less than half women already participate in the market. The above discussion suggests that all aspects of the wage distribution are potentially important for the time allocation decision. The question of theiir relative importance, however, must be addressed with a quantitative analysis, which is what we do in this paper.

Technological improvements in the home production sector also affect the relative returns to work at home and in the market, but the direction of this effect depends on the substitutability of inputs in the home production. Consider a home good, say home-cooked meals, produced by combining home appliances (capital) and labor. In our main framework, capital-augmenting technological change is equivalent to the decline in relative prices of home appliances. If technological progress is capital-augmenting and the inputs are substitutes, then households will allocate less labor to home production. If, on the other hand, the inputs are complements, capital-augmenting technological progress would have the opposite effect.[7]

Thus, we quantitatively assess the importance of changes in the entire earnings distribution, and each of its aspects in isolation, and the decline in prices of home appliances for LFP of married females. Our conclusion is closer to that of Jones et al. (2003). We find that changes in the wage distribution can account for most of the increase in married female labor force participation, and in a manner, consistent with observations on relative leisure of husbands and wives as well as the observation that the participation increase was the greatest for women married to men at the top of the earnings distribution. Most of this result is driven by the closing of the gender wage gap, although other aspects of the wage distribution, in particular, an increase in assortativeness of matching, appear to be responsible for the fact that participation increased more for women married to wealthy husbands. We find that the "revolution" in home production has a much smaller impact on married female labor force participation, accounting for only 5% of its entire increase.

II. Data on Workforce Participation

We use the U.S. Census data on married couples such that each of the spouses is between the ages of 25 and 64. Since we do not model human capital accumulation, we consider only those individuals who had the time to complete their education. The U.S. Census data is available decennially.

We call an individual an earner if this individual works a positive number of hours. Hence, all the couples in the sample can be identified as either two-earner couples, one-earner male couples, one-earner female couples, or no-earner couples. From the discussion in part 1, nearly all the increase in the fraction of the two-earner couples is due to one-earner male couples becoming two-earner couples. Hence, we

[7] Aguiar and Hurst (2006) use the degree of substitutibility of inputs (labor and capital in our case) to classify an activity as home production. Hence, when performing sensitivity analysis, we maintain the assumption that labor and capital are substitutes in home production. Certainly, this assumption gives the best chance to the story of home production *revolution*.

choose to focus only on these two types of couples and eliminate one-earner female couples[8] from the sample used in part 1. Moreover, since one of our objectives is to study the effect of changes in the wage distribution on LFP, we need to estimate the parameters of this wage distribution. By constructing the sample in which only females suffer from selection bias, we significantly simplify the estimation of the wage distribution.

In the remaining sample, all males work positive hours. Moreover, the fraction of two-earner couples among all couples is equivalent to the fraction of working women among all women. Hence, we will use "married female labor force participation" and "fraction of two-earner couples in all couples" interchangeably.

The main observation we investigate is the increase in the fraction of two-earner couples. Notice from Figure 1 that it increased dramatically, from 33% to 76%, in the period between 1959 and 1999. Notably, this increase occurred for households of all income types. Since all male income[9] is observed in the sample, we can split the couples into 10 groups, each one corresponding to the interval of the husband's real income, measured in 1999 dollars.[10] The income intervals are arbitrarily chosen to be $(0, 12,000]$, $(12,000, 24,000)$, $(24,000, 36,000)$, ..., $(108,000, +)$. Figure 3 plots female participation rates by the interval of her husband's real income. Clearly, female participation increased for all groups of couples, but the increase was greater for those females whose husbands are at the top of the income distribution. Indeed, in 1959 less than 10% of females with husbands earning over $108,000$ per year participated in the workforce, while in 1999, this number was over 70%.

Another important fact is that annual hours of work, conditional on working positive hours, did not change nearly as much as female LFP. Indeed, while male hours remained roughly constant, female hours increased by 17%. Since the increase in female LFP was much more dramatic, 130%, we focus solely on the extensive margin.

III. Model

We develop a static, partial equilibrium model of family time allocation. There is measure 1 of heterogeneous households. Each household consists of two people, a male and a female. Agents are heterogenous in their earning ability. In particular, we assume that couples' market wages are drawn from a log-normal distribution, $\left(w_m^i, w_f^i\right) \sim LN\left(\mathbf{m}, \mathbf{S}\right)$, where $\mathbf{m}$ and $\mathbf{S}$ denote the mean vector and the covariance matrix of the log-normal distribution.[11]

All agents are endowed with 1 unit of productive time which is allocated between market work $\left(l^1\right)$, home work $\left(l^2\right)$, and leisure $\left(1 - l^1 - l^2\right)$. All agents have identical preferences over consumption of the market good $\left(c^1\right)$, consumption of the home good $\left(c^2\right)$, and leisure given by

$$u\left(c^1, c^2, l\right) = \mu \log\left(c^1\right) + \nu \log\left(c^2\right) + \left(1 - \mu - \nu\right) \log\left(1 - l^1 - l^2\right).$$

[8] If we allow the households in the model to be of three types and keep all three types of couples in the sample, the main results do not change. Hence, we choose to eliminate the unnecessary complications.

[9] Labor income is defined as wage income for those who work for wages and as business income for self-employed.

[10] We use CPI index to compute real incomes.

[11] The convention is to write $\left(w_m^i, w_f^i\right) \sim LN\left(\boldsymbol{\mu}, \boldsymbol{\Sigma}\right)$, where the parameters are the mean vector and covariance matrix of the underlying normal distribution. Since there is a one-to-one mapping from the moments of the normal to the moments of the log-normal distribution, we believe that our convention is less confusing for the purpose at hand.

The home good is produced according to the CES production function denoted by $F(k,l) = [\theta k^\rho + (1-\theta) l^\rho]^{1/\rho}$, where k denotes the stock of home appliances and l denotes family labor allocated to home work. Home appliances are purchased in the market at the real price q.

All men participate in market production. This modeling choice is motivated by the discussion in the data section. Further, market hours are assumed to be indivisible, i.e., the male works exactly $\bar{l}_m^1$; the female works $\bar{l}_f^1$ if she chooses to participate in the market production.[12] Throughout the paper, individual variables are subscripted by the gender of the individual.

We assume that the bargaining problem within the household is solved efficiently, so that the household's problem can be written as a social planning problem. Let λ represent the relative weight on male utility in the planner's problem. Each household, depending on its choice of time allocation, can be one of the following two types: a one-earner male household (1M) and a two-earner household (2E).

Given the realization (w_m, w_f), each household chooses $\max\{V_{2E}(w_m, w_f), V_{1M}(w_m, w_f)\}$, where

$$\begin{aligned} V_{2E}(w_m, w_f) = \max_{c_m^1, c_m^2, c_f^1, c_f^2, k, l_m^2, l_f^2} & \lambda\left[\mu \log\left(c_m^1\right) + \nu \log\left(c_m^2\right) + (1-\mu-\nu)\log\left(1-\bar{l}_m^1 - l_m^2\right)\right] \\ & + (1-\lambda)\left[\mu \log\left(c_f^1\right) + \nu \log\left(c_f^2\right) + (1-\mu-\nu)\log\left(1-\bar{l}_f^1 - l_f^2\right)\right] \\ & \text{s.t.} \quad c_m^1 + c_f^1 + qk = w_m + w_f, \\ & c_m^2 + c_f^2 \leq F\left(k, l_m^2 + l_f^2\right), \\ & 0 \leq l_m^2 \leq 1 - \bar{l}_m^1, \\ & 0 \leq l_f^2 \leq 1 - \bar{l}_f^1, \end{aligned}$$

and $V_{1M}(w_m, w_f)$ is identical to $V_{2E}(w_m, w_f)$ with $w_f = \bar{l}_f^1 = 0$.

After substituting for the optimal consumption of the market and home good, derived analytically, the above simplifies to

$$\begin{aligned} V_{2E}(w_m, w_f) = \max_{k, l_m^2, l_f^2} & \mu \log(w_m + w_f - qk) + \nu \log\left(F\left(k, l_m^2 + l_f^2\right)\right) \\ & + (1-\mu-\nu)\left[\lambda \log\left(1-\bar{l}_m^1 - l_m^2\right) + (1-\lambda)\log\left(1-\bar{l}_f^1 - l_f^2\right)\right] + \kappa \\ & \text{s.t.} \quad 0 \leq k \leq (w_m + w_f)/q, \\ & 0 \leq l_m^2 \leq 1 - \bar{l}_m^1, \\ & 0 \leq l_f^2 \leq 1 - \bar{l}_f^1, \end{aligned}$$

with $V_{1M}(w_m, w_f)$ again being the special case of $V_{2E}(w_m, w_f)$ with $w_f = l_f^1 = 0$.[13]

Decision Rules

The model implies a very intuitive decision rule. As long as the female's wage is large enough relative to her husband's wage, she will choose to participate in market production. Hence, the wage space is partitioned into two regions: 2E, 1M. We define the threshold between the two regions as a function $L(\cdot)$ such that $V_{1M}(w_m, L(w_m)) = V_{2E}(w_m, L(w_m))$.Figure 5 illustrates the workings of the mechanism. A

[12] Note the hours are different for men and women to allow for a better mapping of observables into the model.

[13] Notice that the constant $\kappa = (\mu+\nu)(\lambda \log \lambda + (1-\lambda)\nu \log(1-\lambda))$ is irrelevant for the household's optimization problem.

point in this space represents a particular realization of (w_m, w_f). All couples with earnings realization above the threshold choose to be 2E couples. The contour plots illustrate how the couples are distributed in the wage space. While the parameters of the joint wage distribution determine where the couples are located in this wage space, it is the rest of the parameters of the model, including the price of home appliances, that determine the shape and location of the threshold. If for some given wage distribution the threshold shifts downward, then the fraction of two-earner couples will go up. Alternatively, the participation can go up for any given threshold when the mass of the distribution shifts to the region of the 2E couples.

Next we demonstrate two special cases of the model for which the decision rule threshold is linear, the first is the case of no home production, and second is the case of the Cobb-Douglas home production. If the production function is general CES, then the threshold is non-linear.

Proposition 1 *In a model with (i) no home production or with (ii) Cobb-Douglas home production function, the threshold is an array from the origin.*

(i) Consider a version of our model with no home production. Preferences in this case are represented by $u\left(c^1, l\right) = \mu \log\left(c^1\right) + (1-\mu-\nu)\log\left(1-l^1-l^2\right)$. The threshold can be easily derived analytically by setting V_{1M} and V_{2M} equal to each other.

$$\begin{aligned}
V_{1M} &= V_{2E} \\
\mu \log(w_m) &= \mu \log(w_m + w_f) + (1-\mu-\nu)(1-\lambda)\log\left(1-\bar{l}_f^1\right) \\
\mu \log\left(\frac{w_m + w_f}{w_m}\right) &= -(1-\mu-\nu)(1-\lambda)\log\left(1-\bar{l}_f^1\right) \\
\frac{w_m + w_f}{w_m} &= \exp\left(\frac{-(1-\mu-\nu)(1-\lambda)\log\left(1-\bar{l}_f^1\right)}{\mu}\right) \equiv A \\
w_f &= w_m (A-1).
\end{aligned}$$

(ii) Now consider a version of our model with Cobb-Douglas home production function, $F(k,l) = k^\theta l^{1-\theta}$. The problem of the two-earner household is

$$\begin{gathered}
V_{2E} = \max_{k, l_m^2, l_f^2} \mu \log(w_m + w_f - qk) + \nu\left[\theta \log k + (1-\theta)\log\left(l_m^2 + l_f^2\right)\right] \\
+(1-\mu-\nu)\left[\lambda \log\left(1-\bar{l}_m^1 - l_m^2\right) + (1-\lambda)\log\left(1-\bar{l}_f^1 - l_f^2\right)\right] \\
\text{s.t.} \quad 0 \le k \le (w_m + w_f)/q, \\
0 \le l_m^2 \le 1-\bar{l}_m^1, \\
0 \le l_f^2 \le 1-\bar{l}_f^1.
\end{gathered}$$

Notice that the optimal k is always interior since the marginal utility from k approaches infinity as k converges to zero. Thus, the optimal k is obtained by solving the first order condition:

$$\frac{\mu q}{w_m + w_f - qk} = \frac{\nu\theta}{k},$$

which yields

$$k = \frac{\nu\theta}{\mu + \nu\theta} \left(\frac{w_m + w_f}{q} \right).$$

It is possible to have corner solutions to the optimal time allocation in home production. First, observe that the household as a whole will always allocate a positive number of hours to home production because of the log utility. Fortunately, we do not need to solve for time allocation to the home production since this allocation is independent of wages. Thus, the value function becomes

$$\begin{aligned} V_{2E} &= \mu \log \left(w_m + w_f - \frac{\nu\theta \left(w_m + w_f \right)}{\mu + \nu\theta} \right) + \nu\theta \log \left(\frac{\nu\theta}{\mu + \nu\theta} \left(\frac{w_m + w_f}{q} \right) \right) + \text{constant}, \\ V_{2E} &= \left(\mu + \nu\theta \right) \log \left(w_m + w_f \right) + C\left(2E \right), \end{aligned}$$

where $C(2E)$ is some constant. Similarly, the solution to $1M$ problem is

$$V_{1M} = \left(\mu + \nu\theta \right) \log \left(w_m \right) + C\left(1M \right).$$

Equating the two value functions gives

$$\begin{aligned} \left(\mu + \nu\theta \right) \log \left(w_m + w_f^* \right) + C\left(2E \right) &= \left(\mu + \nu\theta \right) \log \left(w_m \right) + C\left(1M \right), \\ \log \left(\frac{w_m + w_f}{w_m} \right) &= \frac{C\left(1M \right) - C\left(2E \right)}{\mu + \nu\theta}, \\ \frac{w_m + w_f}{w_m} &= \exp \left(\frac{C\left(1M \right) - C\left(2E \right)}{\mu + \nu\theta} \right). \end{aligned}$$

Clearly, the solution to this equation, $w_f^* = L\left(w_m \right)$, is a linear function of w_m.

Proposition 2 *In the model with CES home production function, capital-augmenting technological progress in home production is equivalent to the decile in the price of home appliances.*

Proof. In this version of the model, $F\left(k, l \right) = \left[\theta \left(Ak \right)^\rho + \left(1 - \theta \right) l^\rho \right]^{1/\rho}$. We want to show that an increase in A is equivalent to a proportional decrease in q. Define the new variable $\tilde{k} \equiv qk$ and rewrite the problem of the two-earner household as follows,

$$\begin{aligned} V_{2E} = \max_{c_m^1, c_m^2, c_f^1, c_f^2, \tilde{k}, l_m^2, l_f^2} & \lambda \left[\mu \log \left(c_m^1 \right) + \nu \log \left(c_m^2 \right) + \left(1 - \mu - \nu \right) \log \left(1 - \bar{l}_m^1 - l_m^2 \right) \right] \\ & + \left(1 - \lambda \right) \left[\mu \log \left(c_f^1 \right) + \nu \log \left(c_f^2 \right) + \left(1 - \mu - \nu \right) \log \left(1 - \bar{l}_f^1 - l_f^2 \right) \right] \\ & \text{s.t. } \; c_m^1 + c_f^1 + \tilde{k} = w_m + w_f, \\ & c_m^2 + c_f^2 \leq \left[\theta \left(A \frac{\tilde{k}}{q} \right)^\rho + \left(1 - \theta \right) \left(l_m^2 + l_f^2 \right)^\rho \right]^{1/\rho}, \\ & 0 \leq l_m^2 \leq 1 - \bar{l}_m^1, \\ & 0 \leq l_f^2 \leq 1 - \bar{l}_f^1. \end{aligned}$$

It is clear that A and q enter in this problem as a ratio. Hence, increasing A by a factor of λ is equivalent to decreasing q by the same factor. The same proof holds for V_{1M}. ■

Hence, the experiment of dropping the relative price of home appliances, q, that we discuss in the later section can be interpreted as a capital-augmenting technological change in home production.

IV. Calibration

For computational accuracy, it is convenient to work with logs of the wages (normal space), not with wages directly (log-normal space). Let $X = \log(w_m)$ and $Y = \log(w_f)$, so that $(X, Y) \sim N(\boldsymbol{\mu}, \boldsymbol{\Sigma})$, where[14]

$$\boldsymbol{\mu} = \begin{bmatrix} \mu_X \\ \mu_Y \end{bmatrix}, \quad \boldsymbol{\Sigma} = \begin{bmatrix} \sigma_X^2 & \sigma_{XY} \\ \sigma_{XY} & \sigma_Y^2 \end{bmatrix}.$$

Accordingly, we transform our sample by taking logs.

Figure 2 shows the average annual working hours of male and female in our sample. We calibrate the fixed work hours (conditional on working) of males and females in 1999, $\bar{l}_m^1$ and $\bar{l}_f^1$, to be 0.44 and .34 respectively, to match their data counterparts. McGrattan et al. (1997) estimated the parameters of the home production function to be $\theta = 0.206$ and $\rho = 0.189$. We then fix the preference parameters at $\lambda = 0.5,\ \mu = 1/3,\ \nu = 1/3$. The remaining parameters are the parameters of the wage distribution, $\mu_X, \mu_Y, \sigma_X, \sigma_Y, \sigma_{XY}$, and the relative price of home appliances q.

We proceed in two steps. First, we calibrate the remaining six parameters using the method of moments to match some key moments in 1999. More precisely, we calibrate the remaining six parameters by minimizing the distance between the relevant moments in the data, summarized in Table 1, and the corresponding moments implied by the model.

Table 1: Summary of Moments Used for Calibration

Preferences	Definition
$P(1M)$	Fraction of 1M couples
$E[X]$	Mean of log of male wages
$Var[X]$	Variance of log of male wages
$E[Y \mid 2E]$	Mean of log of female wages, conditional on being a 2E couple
$Var[Y \mid 2E]$	Variance of log of female wages, conditional on being a 2E couple
$P(1M \mid X \leq \mu_X)$	Fraction of 1M among couples with $\log(w_m)$ below median

Let the vector of the above moments be denoted by $\mathcal{M}$ and let the vector of corresponding moments in the model be denoted by $M(\Theta)$, where $\Theta = \{\mu_X, \mu_Y, \sigma_X, \sigma_Y, \sigma_{XY}, q\}$. We calibrate Θ by solving the problem

$$\min_{\Theta} \left[\mathcal{M} - M(\Theta)\right]' W \left[\mathcal{M} - M(\Theta)\right],$$

where W is the identity matrix. In order to solve this minimization problem we need to adopt an efficient numerical technique for computing various conditional moments in the model. For more details

[14] There is a unique one-to-one mapping from $(\boldsymbol{\mu}, \boldsymbol{\Sigma})$ to $(\mathbf{m}, \mathbf{S})$. The formulas are shown in the appendix.

on computation see the appendix[15].

Table 2 provides a summary of the calibrated parameters for the year 1999.

Table 2: Summary of Calibrated Parameters for 1999

	Value	Definition
Preferences		
λ	0.5	Weight on male in the planner's problem
μ	1/3	Weight on utility from market good
ν	1/3	Weight on utility from home good
Market hours		
$\bar{l}_m^1$	0.44	Fixed market time for working male
$\bar{l}_f^1$	0.34	Fixed market time for working female
Home production		
θ	0.206	Share parameter
ρ	0.189	CES parameter
Wage distribution		
μ_X	10.374	Mean of log wage of male
μ_Y	9.5586	Mean of log wage of female
σ_X	0.86894	Std. of log wage of male
σ_Y	1.2346	Std. of log wage of female
σ_{XY}	0.66739	Covariance of log wages of couples
Other		
q	0.99586	Price of home appliances

The next step is to estimate the time series for the parameters of the wage distribution $(\mathbf{m}_t, \mathbf{S}_t)$, $t = 1959, 1969, ..., 1999$. If we fully observed wages of all husbands and wives we would estimate the wage distribution using the classical method of moments. In order to predict the unobserved wages in our sample, we use the censored regression model in conjunction with the threshold implied by our model. Once the unobserved wages are predicted, we can infer the remaining parameters of the wage distribution from their sample counterparts.

The structure of our model suggests a version of the Tobit model, with the censoring rule determined by the model. Formally, our estimation procedure is described by

$$\begin{aligned} y_i^* &= x_i\beta + u_i, \quad u_i \sim N\left(0, \sigma^2\right) \\ y_i &= \begin{cases} y_i^* & \text{if} \quad y_i^* > f\left(z_i, \Omega\right) \\ 0 & \text{otherwise} \end{cases} \end{aligned}$$

where y_i^* denotes the log of the market wage offer to a married female i and x_i denotes her personal attributes such as education level, experience, etc., that determine her earning ability. The observed log

[15] Supplemental Notes, available through the authors' websites, explain the computation of the model moments and numerical integration methods. The difficulty with this is that the limit of integration, i.e., the threshold between the 1M and 2E regions, has to be computed for every point at which we evaluate the integrand. This threshold must be computed numerically by equating the value functions of the 2E and 1M problems, which in turn may have corner solutions.

of wage earnings of a married female i is denoted by y_i. The (observed) log of the market wage of the husband is denoted by z_i. The censoring rule, $y_i^* > f(z_i, \Omega)$ is determined within our model, with an explicit dependence on husband's income z_i and parameters of the model Ω, in particular, the technology and preferences parameters and price of home appliances. The wife's wage is observed if it is above the threshold implied by the model. In our model, the function f denotes the threshold in the space of the log wages. Thus, our version of the Tobit model consists of a Mincer regression, $y_i^* = x_i\beta + u_i$, and the censoring rule as determined within our model.

The log likelihood function

$$\begin{aligned}
\Pr(y_i = 0) &= \Pr(x_i\beta + u_i \leq f(z_i)) \\
&= \Pr\left(\frac{u_i}{\sigma} \leq \frac{f(z_i) - x_i\beta}{\sigma}\right) \\
&= \Phi\left(\frac{f(z_i) - x_i\beta}{\sigma}\right)
\end{aligned}$$

Thus, the contribution to the log-likelihood function made by observations with $y_i = 0$ is $\log\left(\Phi\left(\frac{f(z_i)-x_i\beta}{\sigma}\right)\right)$.

Conditional on $y_i > 0$, the density of y_i is $f(y_i|y_i > 0) = \frac{f(y_i)}{\Pr(y_i>0)} = \frac{\phi((y_i^*-x_i\beta)/\sigma)}{\sigma \Pr(y_i>0)}$. Thus, the log-likelihood function[16] can be written as follows

$$\begin{aligned}
\log L &= \sum_{y_i>0} \log\left(\frac{1}{\sigma}\phi\left(\frac{y_i^* - x_i\beta}{\sigma}\right)\right) + \sum_{y_i=0} \log\left(\Phi\left(\frac{f(z_i) - x_i\beta}{\sigma}\right)\right) \\
&= \sum_{y_i>0} -\frac{1}{2}\left[\log(2\pi) + \log\sigma^2 + \frac{y_i - x_i\beta}{\sigma^2}\right] + \sum_{y_i=0} \log\left(\Phi\left(\frac{f(z_i) - x_i\beta}{\sigma}\right)\right).
\end{aligned}$$

The Tobit model is used to predict the wages of those wives who do not work in the market. Once this is done, we obtain a sequence $(\mathbf{m}_t, \mathbf{S}_t)$, $t = 1959, 1969, ..., 1999$. Table 3 shows the estimated mean wages, coefficients of variation (used to measure within-gender inequality), correlation, and gender wage gap.

Table 3: Selected Estimates of the Wage Distribution

Parameter\year	1959	1969	1979	1989	1999
$E(w_m)$	36712	47597	47382	48078	52888
$E(w_f)$	6779	11434	13702	18958	23739
$SD(w_m)/E(w_m)$	0.781	0.744	0.769	0.849	1.035
$SD(w_f)/E(w_f)$	1.212	0.997	0.977	0.956	1.075
$Corr(w_m, w_f)$	0.004	0.042	0.052	0.143	0.159
$E(w_f)/E(w_m)$	0.185	0.240	0.289	0.394	0.449

[16] Using Olsen's (1978) reparameterization, $\theta = 1/\sigma$, $\gamma = \beta/\sigma$, we get

$$\log L = \sum_{y_i>0} -\frac{1}{2}\left[\log(2\pi) - \log\theta^2 + (\theta y_i - x_i\gamma)^2\right] + \sum_{y_i=0} \log(\Phi(f(z_i) - x_i\gamma)).$$

The Hessian is always negative definite, and Newton's method always converges quickly.

Notice that the estimated gender wage gap increases monotonically, in contrast to the pattern in the observed gender wage gap which is roughly constant between 1959 and mid 1980. The gender wage gap that we report may seem low because we do not control for differences in hours worked or differences in personal characteristics. Adjusting for the average hours worked would obtain the estimated gender wage gap in 1999 to be 0.55. The coefficient of variation is a standard measure of inequality. Our estimates suggest that within-gender inequality increased for males and slightly decreased for females. Also, notice that the estimated correlation of husbands' and wives' wages increases over time, although remaining at a very low level even today. In the next section we measure the relative importance of the above changes for the labor force participation of married women.

V. Quantitative results

In order to isolate the impact of various aspects of the wage distribution on the participation of married women in the market, we construct experiments that correspond to (1) closing of the gender wage gap, (2) change in within-gender inequality, and (3) change in the assortativeness of matching. We choose to focus on three aspects of the wage distribution, the mean vector ($\mathbf{m}$), the coefficients of variation[17] (CV), and the correlation (ρ). We then associate the closing of the gender wage gap with changes in the mean while keeping the coefficient of variation and the correlation fixed. Similarly, the change in within-gender inequality corresponds to changes in the coefficients of variation, while keeping the means and correlations fixed, and the change in the assortative matching corresponds to changing the correlation, while keeping the means and the coefficients of variation fixed. We now demonstrate how we construct the above experiments.

Closing of the gender wage gap. In this experiment we let the estimated means of husbands and wives wages vary across time in accordance with the data, while adjusting the variances and the covariance of the distribution such that the correlation and the coefficient of variation remain fixed at base year values.

Changes in within-gender inequality. In this experiment we would like to change the coefficients of variation, without changing the means or the correlation. This again means that the variances and the covariance have to adjust in an obvious way.

Changes in assortative matching. Here we would like to change the correlation alone, without changing the CV or the means. Since both the means and the CV are fixed during the experiment, this implies that the standard deviations are fixed as well. Therefore, this experiment reduces to changing the covariance.

In the next subsections we describe the results of five experiments and compare them to the data. The experiments are:

Exp 1: Change in the entire wage distribution

Exp 2: Closing of the gender wage gap

Exp 3: Changes in within-gender inequality

[17] The coefficient of variation is the ratio of the standard deviation to the mean. It is widely used as a measure of dispersion that has the desired property of being unit free. Another widely used measure of dispersion with the same property is the standard deviation of the log.

Exp 4: Changes in assortativeness of matching

Exp 5: Revolution in home production

In all the figures we use 1999 as the starting point for the experiments, and go backwards. As mentioned in the calibration section, the reason for doing that is that the selection bias is smaller in 1999 because of higher women's participation.

Figure 6 summarizes the impact of each of the above experiments on the evolution of the fraction of 2-earner couples in the model compared with the data.

First notice that in 1999 the fraction of 2-earner couple in the model does not exactly match this fraction in the data. The reason is that we use the estimated moments of the wage distribution in all the experiments and in all years, including 1999. Recall that the model was calibrated to 1999 in order to use the resulting decision rule threshold as a selection rule in a version of the Tobit model. The estimated Tobit regression was then used to predict the unobserved wages of non-working females, and the completed sample was then used to estimate the wage distribution for all years. Therefore, there is a mismatch in the fraction of 2-earner couples at the initial point between the data (76%) and the model (74.7%). In what follows, we will be comparing the changes generated by different experiments in the model with the corresponding changes in the data, as opposed to the actual values.

The overall change in the fraction of 2-earner couples in the data is 79%[18]. We see that change in the wage distribution (experiment 1) generates a smaller change, of about 70%. We say that as a result of the first experiment, the model account for 88% (that is, 70% out of 79%) of the observed change in the fraction of 2-earner couples. Similarly, the second experiment, i.e., closing of the gender wage gap, accounts for 72% of the observed change in that fraction. Other aspects of the wage distribution have a much smaller impact on women's participation in our model, with the change in within-gender inequality accounting for 10%, and the assortative matching for 4%. Finally, the decline in the relative price of home appliances, experiment 5, accounting for 5% of the observed change in the fraction of 2-earner couples observed in the data. Notice, however, that the impact of the 3rd experiment (changes in within-gender inequality) is non-monotone. It generates an increase in participation in all decades except during the 90's. The biggest increase in participation occurs between 1959-1969.

In the next sections we describe the cross-sectional implications of our experiments, and contrast the results with the data.

A. *Changing*_$(\mathbf{m}, \mathbf{S})$

Figure 3 shows the fraction of 2-earner couples by intervals (of length \$12,000) of husband's real[19] labor income for different years in the data.

Observe that the women's participation increased for almost all intervals of husband's income, except for the second interval [12,000 - 24,000] between 1989 and 1999. As suggested in Bar and Leukhina (2005), this is probably due to the large expansion of the earned income tax credit between 1989 and 1999. Also notice that the magnitude of the increase is larger for women married to higher earning husbands.

[18] Since the starting point for our experiments is 1999, we use the midpoint formula for percentage changes in the model as and in the data. We find it less confusing than reporting the percentage "drop" from 1999 to 1959.

[19] All the magnitutes are in 1999 dollars.

The analog of the Figure 3 for the first experiment is shown in the Figure 7.

Notice that as a result of the change in all the aspects of the wage distribution, wives' participation went up in the model for all intervals of husband's income, with the increase being higher for women married to higher income husbands. The model however generates participation rates that are too high for low income intervals and too low for high income intervals. This might be due to functional form of the utility function, i.e., the log utility, which forces women (in the model) that are married to low income husbands, to participate in the market. Another reason for this result might be that in the real world, couples with low labor income, have other sources of income that are absent in the model. An example of this sort of income could be dividend income, which results from past investment decisions not captured by our model, and are topics for future research.

B. Closing of the gender wage gap

Figure 9 presents the impact of closing gender wage gap (second experiment). As expected, the graphs look very similar to the first experiment, since we have already seen that closing of the gender wage gap has the biggest impact compared to other aspects of the wage distribution.

C. Within-Gender Inequality

In this experiment we change the coefficient of variation in accordance with the data, while keeping the other aspects of the wage distribution fixed. The results are displayed in Figure 11. Notice that the biggest effect on participation is during the 60's, accounting for 24% of the observed change. Observe from Table 10.3 that the biggest change in the coefficients of variation occured in the 60's.

D. Assortative matching

Table 4 shows the estimated correlation between the wages of the spouses in the data.

Table 4: Evolution of Assortativeness of Matching

year	1950	1969	1979	1989	1999
$Corr\,(w_m, w_f)$	0.0043	0.042	0.052	0.1434	0.1593

We find that after correcting for selection bias with our model, the correlation is fairly low. There has been a constant increase in assortativeness of matching though. Figure 13 shows the impact of the change in the correlation between wages of husbands and wives.

Our model implies that wives will tend to participate in the market if their wage offer is high enough compared to their husband's. Therefore, one would expect that for couples in which the husband earns above the mean, an increase in correlation will increase women's participation, and for couples with husbands wages below the mean, an increase in correlation will decrease the participation.

E. Revolution in Home Production

National Income and Product Accounts provide detailed price indices for numerous components of the personal consumption expenditure. Based on those price indices, the relative price of durable consumption to non-durable consumption halved in the period under consideration. The change in the more narrow category, "Furniture and household equipment[20]" was more dramatic. Figure **??** depicts those two time series.

It should be noted, however, that the relative price of housing operation, a category that includes electricity, gas, telephone, water, and other domestic services, did not decline over time. The experiment that we actually perform is setting q_{1999} to be equal to the calibrated value and letting it change as we go back to 1959 in accordance with the price index of appliances. The results are in the next graph.

The fall in the price of appliances generates an increase in wives' participation for all levels of husbands' incomes, although a modest one. It seems that the impact on middle and high income couples is greater than that on the lower income.

****

1. Data on leisure for a similar data sample is to be completed and compared to the predictions of the model as given in Figures 17-20.

2. Robustness with respect to technology and preference parameters is to be completed

3. 2 alternative (or additional) methodologies that we are working on are to be added as a part of robustness check

VI. Conclusions

The goal of this paper was to quantitatively assess two channels that can theoretically affect married female labor force participation. A model of family time allocation decision-making is used, in which the agents are heterogeneous with respect to their earning ability. Heterogeneity allows us to test the cross-sectional implications of the competing theories against the data.

To estimate the parameters of the joint wage distribution of husbands and wives, we use a censored regression model in conjunction with our model. We find that changes in the wage distribution can account for 88% of the increase in the fraction of two-earner couples among all married couples. This accounting is mainly due to the closing of the gender wage gap, although other aspects of the wage distribution play an important role in matching the pattern of female participation by interval of husband's income. Lastly, we find that the quantitative effect of the revolution in home production is small, accounting for 5% of the changes in married female participation.

Appendix

Derivations for the Simplified Economic Mechanism

[20] This category includes: (1) Furniture, including mattresses and bedsprings, (2) Kitchen and other household appliances, (3) China, glassware, tableware, and utensils, (4) Video and audio goods, including musical instruments, and computer goods, (5) Computers, peripherals, and software, (6) Other durable house furnishings.

The relationship between the moments of the log-normal and the underlying normal distributions is given by:

$$\begin{aligned}
\mu_1 &= \log\left(\frac{m_1^2}{\sqrt{m_1^2+s_{11}}}\right),\ \mu_2 = \log\left(\frac{m_2^2}{\sqrt{m_2^2+s_{22}}}\right) \\
\sigma_1^2 &= \log\left(1+\frac{s_{11}}{m_1^2}\right),\ \sigma_2^2 = \log\left(1+\frac{s_{22}}{m_2^2}\right),\ \sigma_{12} = \log\left(1+\frac{s_{12}}{m_1 m_2}\right)
\end{aligned}$$

Substituting in Z gives

$$\text{(1)} \qquad \frac{\log\left(\frac{m_2^2}{\sqrt{m_2^2+s_{22}}}\right) - \log\left(\frac{m_1^2}{\sqrt{m_1^2+s_{11}}}\right) - \log(a)}{\sqrt{\log\left(1+\frac{s_{22}}{m_2^2}\right) + \log\left(1+\frac{s_{11}}{m_1^2}\right) - 2\log\left(1+\frac{s_{12}}{m_1 m_2}\right)}}$$

Consider the numerator of (1) first,

$$\begin{aligned}
&\log\left(\frac{m_2^2}{\sqrt{m_2^2+s_{22}}}\right) - \log\left(\frac{m_1^2}{\sqrt{m_1^2+s_{11}}}\right) - \log(a) \\
=\ & 2\log(m_2) - \frac{1}{2}\log\left(m_2^2+s_{22}\right) - 2\log(m_1) + \frac{1}{2}\log\left(m_1^2+s_{11}\right) - \log(a) \\
=\ & 2\log\left(\frac{m_2}{m_1}\right) + \frac{1}{2}\log\left(\frac{m_1^2+s_{11}}{m_2^2+s_{22}}\right) - \log(a) \\
=\ & 2\log\left(\frac{m_2}{m_1}\right) + \frac{1}{2}\log\left(\left(\frac{m_1^2}{m_2^2}\right)\left(\frac{1+\frac{s_{11}}{m_1^2}}{1+\frac{s_{22}}{m_2^2}}\right)\right) - \log(a) \\
=\ & 2\log\left(\frac{m_2}{m_1}\right) + \frac{1}{2}\log\left(\frac{m_1^2}{m_2^2}\right) + \frac{1}{2}\log\left(\frac{1+\frac{s_{11}}{m_1^2}}{1+\frac{s_{22}}{m_2^2}}\right) - \log(a) \\
=\ & \log\left(\frac{m_2}{m_1}\right) + \frac{1}{2}\log\left(\frac{1+CV(w_m)^2}{1+CV(w_f)^2}\right) - \log(a) \\
=\ & \log(GWG) + \frac{1}{2}\log\left(1+CV(w_m)^2\right) - \frac{1}{2}\log\left(1+CV(w_f)^2\right) - \log(a).
\end{aligned}$$

Where $CV(w) = SD(w)/E(w)$ is the coefficient of variation and GWG is the gender wage gap.

Consider the denominator of (1),

$$\begin{aligned}
&\sqrt{\log\left(1+\frac{s_{22}}{m_2^2}\right) + \log\left(1+\frac{s_{11}}{m_1^2}\right) - 2\log\left(1+\frac{s_{12}}{m_1 m_2}\right)} \\
=\ & \sqrt{\log\left(1+CV(w_f)^2\right) + \log\left(1+CV(w_m)^2\right) - 2\log\left(1+\frac{\rho(w_m,w_f)\,SD(w_m)\,SD(w_f)}{m_1 m_2}\right)} \\
=\ & \sqrt{\log\left(1+CV(w_f)^2\right) + \log\left(1+CV(w_m)^2\right) - 2\log\left(1+AM\cdot CV(w_m)\cdot CV(w_f)\right)}
\end{aligned}$$

where $AM \equiv \rho(w_m, w_f)$ is our measure of the assortative matching.

Data on Labor Force Participation

We download the 1960, 1970, 1980, 1990, 2000 U.S. Census data from IPUMs. Most of the census questions relevant to this project refer to the previous years, i.e. 1959, 1969, ..., 1999. We keep only married non-farm individuals of ages $[25-64]$ whose spouse is present and translate all incomes into 1999 dollars using 12 months averages of seasonally adjusted CPI,

Table 5: Consumer Price Index

1959	1969	1979	1989	1999
29.17	36.68	72.58	123.94	166.58

We then create time series that are natural logs of all income types.

We do not correct for topcoding in 89 and 99 because the topcoded observations are already replaced by state mean or median. Hence, we only correct for 59, 69, 79. Using the mean and SD of the truncated distribution of logs of male annual wage incomes, the level of the topcode, and the assumption of the normality of this distribution, we compute the expected mean in the tail of the male wage distribution. The results are reported below.

Table 6: Correction For Topcoding

year	μ_X truncated	σ_X, truncated	topcode: a	correction: $E[X\|X>a]$
1959	10.19074	0.6695618	11.86896571	12.09612871
1969	10.48966	0.6622401	12.33302225	12.53615899
1979	10.46222	0.7789073	12.05602852	12.39249818

We then replace the topcoded male annual wage income with $E[X|X>a]$. We then replace the topcoded female annual wages with a*mean(wage of female)/mean(wage of male) of those individuals whose wage exceeds the mean of male wages and excluding those with topcoded wage income. We deal with topcoded observations of other incomes in the same manner we deal with female wage income.

Once we correct for topcoding we create a new labor income variable

$$\text{Labor Income} = \text{Wage Income} + \text{Business Income} + \text{Farm Income}$$

and drop individuals with negative labor incomes.

We finally need to deal with intervalled variables. Actual weeks worked last year and usual weekly hours worked last year are available since 1979 only. For 1959 and 1969 we are forced to use intervalled counterparts of these series. The objective is to figure out the right midpoints for each of the intervals. To do so we use 1979 data on actual and intervalled series and compute averages for each interval.

Table 7: Availability of Data on Worktime

	1959	1969	1979	1989	1999
Actual Hours	NA	NA	Available	Available	Available
Intervalled Hours	Available	Available	Available	Available	NA
Actual Weeks	NA	NA	Available	Available	Available
Intervalled Weeks	Available	Available	Available	Available	Available

We get different midpoints for men and women.

We drop people with a mismatch between hours and income, i.e. positive hours but negative incomes or vice versa. We drop people with a mismatch between hours and income, i.e. positive hours but negative incomes or vice versa. We then match husbands and wives. Here we keep the following variables: year, household weight, personal weight, husband's and wife's labor incomes last year, their hours, age, race, education record, number of children ever born and number of children under five at home, and class of work (whether they are self-employed, work for wage, or neither), and weeks worked last year.

The number of observations[21] (couples) that we end up with is given by

Table 8: Original Sample Size

Sample 1: year	# couples
1959	21,897,992
1969	24,218,210
1979	34,481,282
1989	37,712,472
1999	42,328,021

We drop the no earner couples (both husband and wife work 0 hours and earn 0 income). After this the number of available observation changes as follows:

Table 9: Final Sample Size

Sample 2: year	# couples	fraction of Sample 1 couples dropped
1959	21,449,563	0.020478088
1969	23,623,713	0.02454752
1979	33,093,874	0.040236555
1989	36,280,387	0.037973777
1999	40,794,924	0.036219435

We then drop the 1F couples from the sample obtained for Essay 1. The reason for doing this is as follows. One experiment we perform is changing the joint wage distribution of husbands and wives. To

[21] IPUMS (9) provides a 1% weighted sample of the total population of each census. We use the household's weights in order to campute the number of households in the total population that our sample represents.

estimate the parameters of this distribution we need to correct for the selection bias using our model. It is impossible to do so if we have the selection bias problem for both, males and females. Hence, we only consider the changes in the patterns of 1M and 2E couples. After we this the number of available observation changes as follows:

Table 10: Sample Size

Sample 3: year	# couples	fraction of Sample 2 couples dropped
1959	21,204,617	0.011419627
1969	23,248,014	0.01590347
1979	32,011,871	0.032694963
1989	34,907,676	0.037836173
1999	38,854,217	0.047572267

The only people with a mismatch of hours and weeks are some women in 1959 and 1969, whose hours are zero but number of weeks worked is positive. For each of these years these women are less than 0.4% of the sample. We replace these women's weeks worked with a 0.

We also change the education attainment variable (weducrec and heducrec) to years of schooling using the following assumptions:

Table 11: Educational Record

	Education code (given)	Years of schooling (assumption)
None or preschool	1	0
Grade 1, 2, 3, or 4	2	3
Grade 5, 6, 7, or 8	3	7
Grade 9	4	9
Grade 10	5	10
Grade 11	6	11
Grade 12	7	12
1 to 3 years of college	8	14
4+ years of college	9	18

Estimating $\mu_X, \mu_Y, \sigma_X, \sigma_Y, \sigma_{XY}$ for the Experiments

We need to estimate $\mu_X, \mu_Y, \sigma_X, \sigma_Y, \sigma_{XY}$ to be used for one of the experiments in this paper.

We use the Tobit model to do so which consists of the wage equation and the participation equation (see the main text).

We use the Mincer regression for the wage equation,

where Y_2E_y is ln(Annual Income of working females).

Race has 9 codes. We define two dummy variables: white and black, as follows.

Table 12: Wage Equation

LHS	RHS
Y_2E_y	years of schooling
	experience
	experience^2
	black_id
	white_id
	X_y

Table 13: Race Codes

Race	Code	Dummy for white	Dummy for black
White	1	1	0
Black	2	0	1
American Indian	3	0	0
Chinese	4	1	0
Japanese	5	1	0
Other Asian or Pacific Islander	6	1	0
Other race, n.e.c.	7	0	0
Two major races	8	0	0
Three or more major races	9	0	0

For the participation equation we use the threshold predicted by the model. This thresholds depends on the deep parameters of the model that we keep fixed as calibrated and on q. We change q according to the data. However, the threshold is not very sensitive to q so the result does not depend on it.

Then we use the results of the regression to predict $Y = \ln(\text{annual income})$ of women-non-workers. We then use the now completed observations of Y to record the sample counterparts of $\mu_X, \mu_Y, \sigma_X, \sigma_Y, \sigma_{XY}$.

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Figure 1: Labor Force Participation of Married Couples

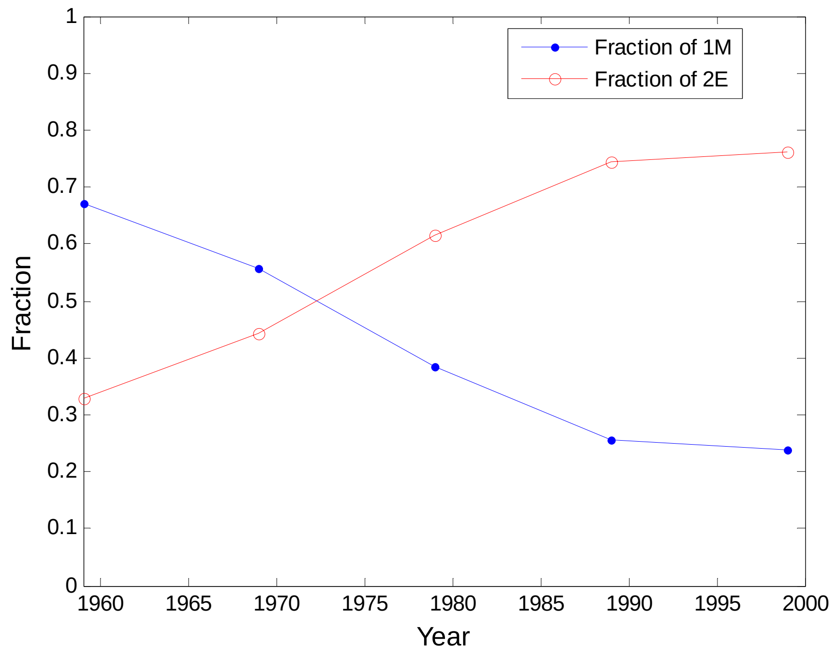

Figure 2: Hours of Work Conditional on Working

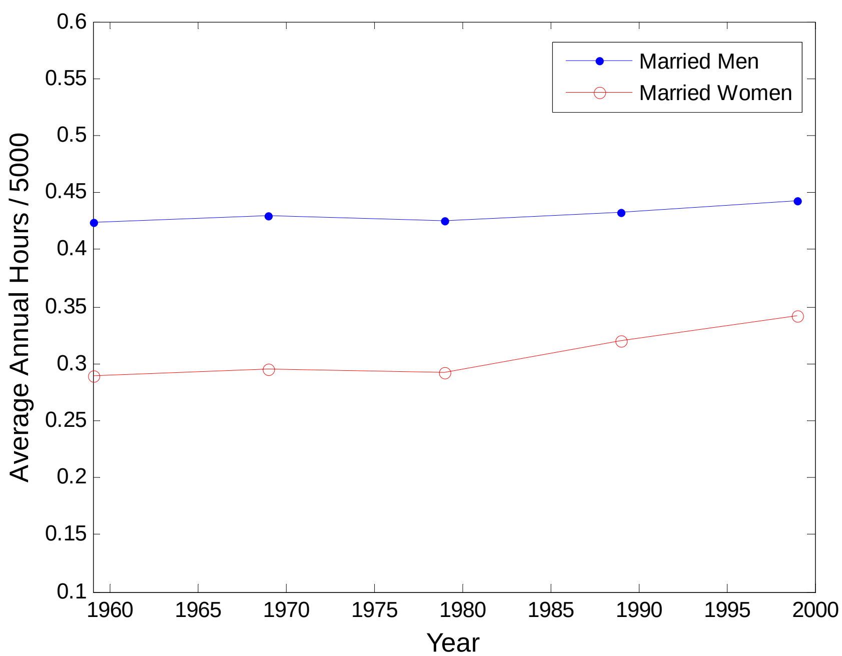

Figure 3: Data: P(2E) by Interval of Husband's Real Labor Income

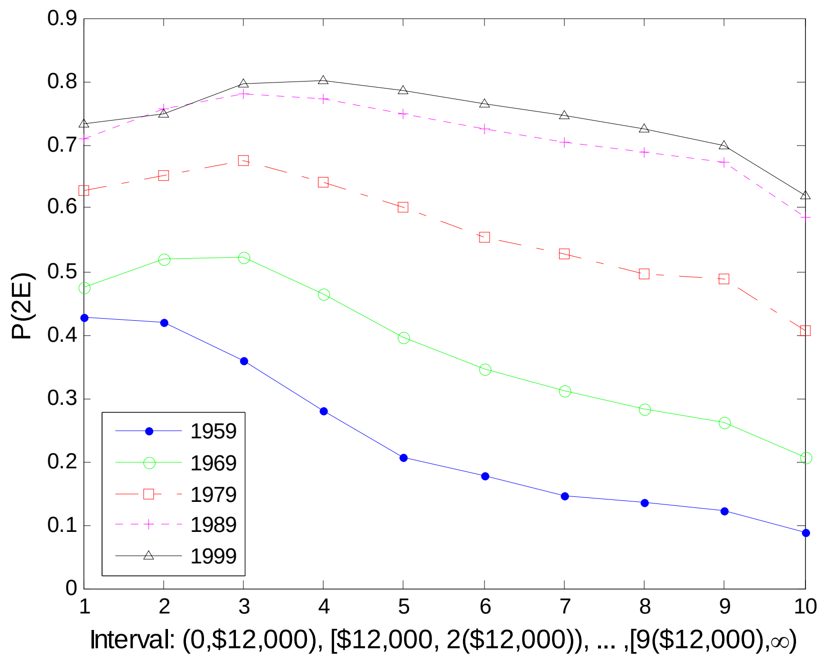

Figure 4: Data: P(2E) by Interval of Husband's Real Labor Income / Average

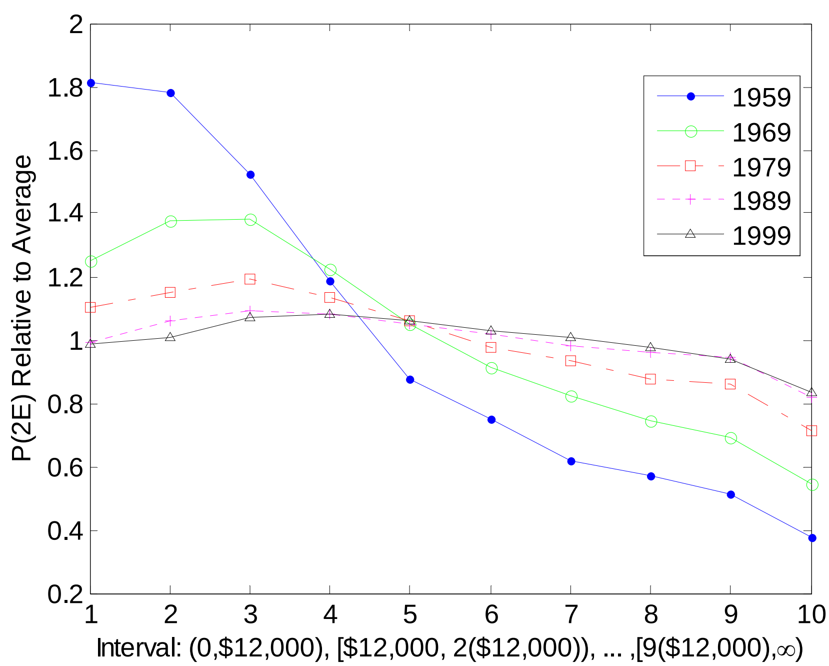

Figure 5: Decision Rules and Location of the Couples

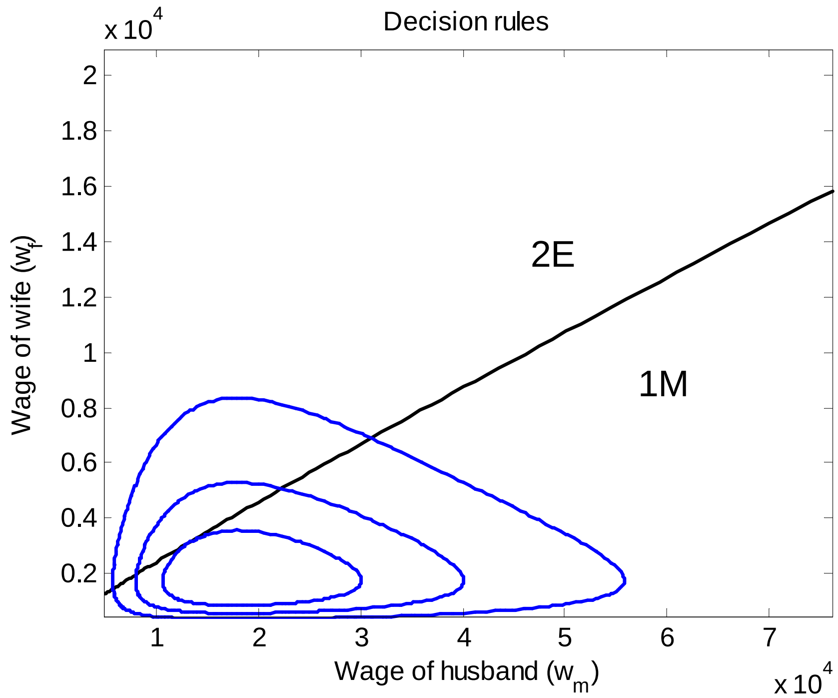

Figure 6: Labor Force Participation of Married Couples: Model v. Data

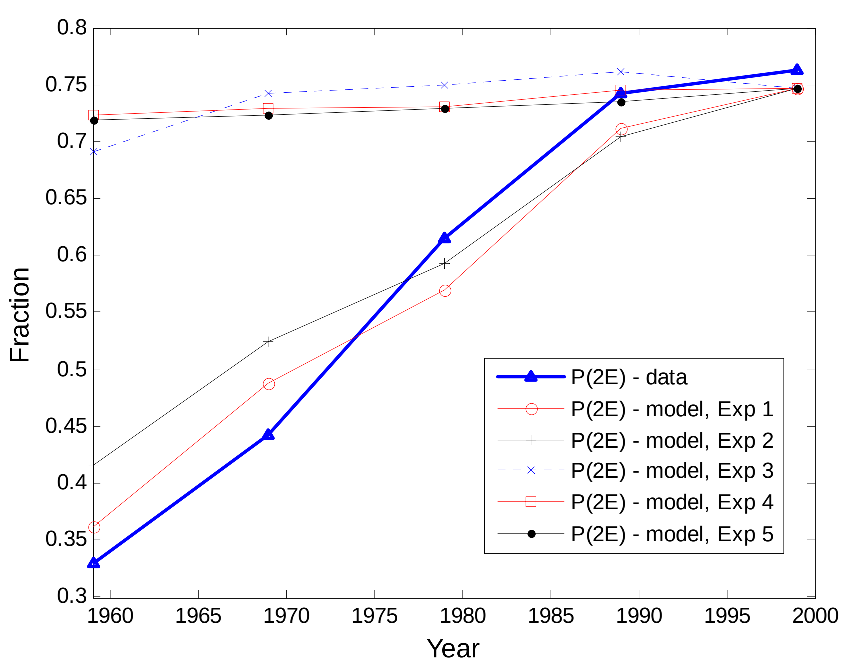

Figure 7: Model Exp 1: P(2E) by Interval of Husband's Real Labor Income

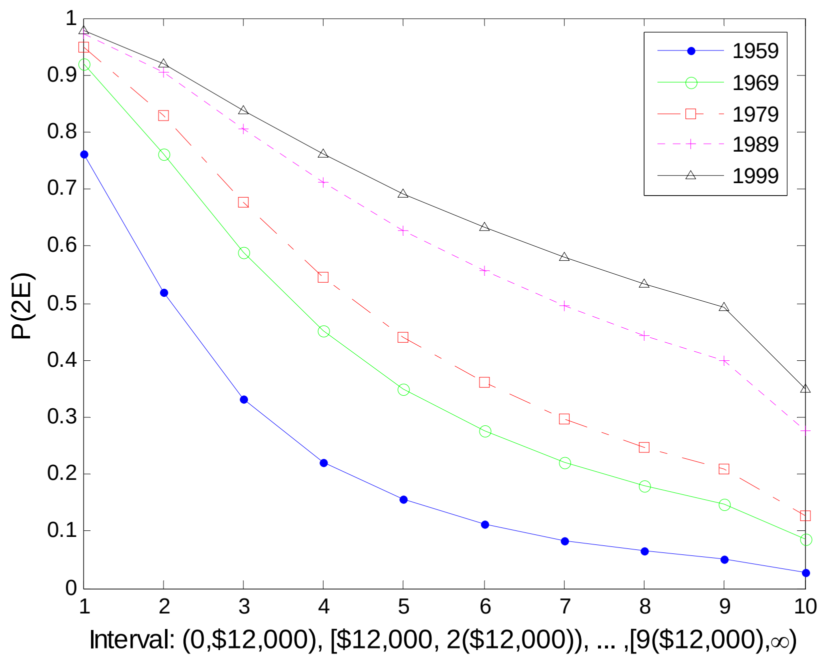

Figure 8: Model Exp 1: P(2E) by Interval of Husband's Real Labor Income / Average

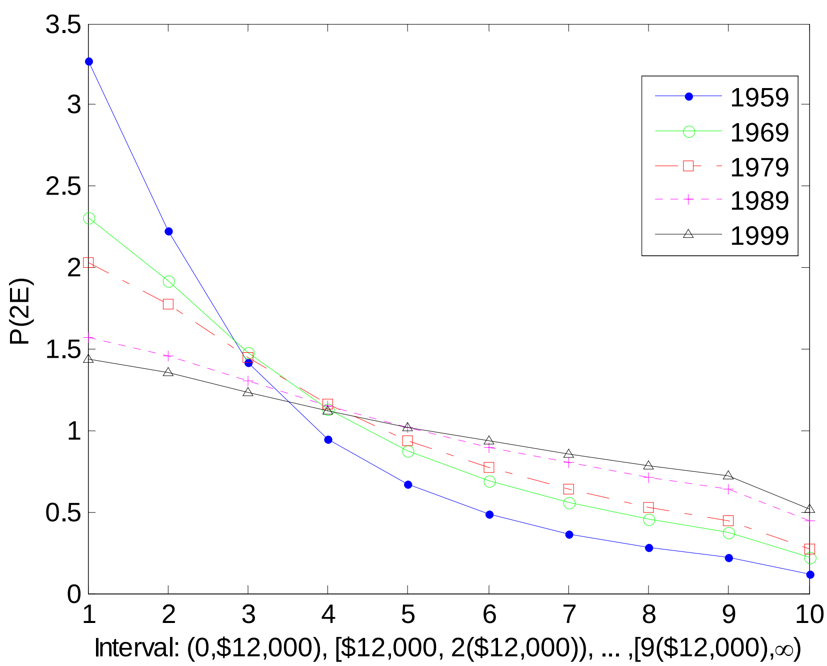

Figure 9: Model Exp 2: P(2E) by Interval of Husband's Real Labor Income

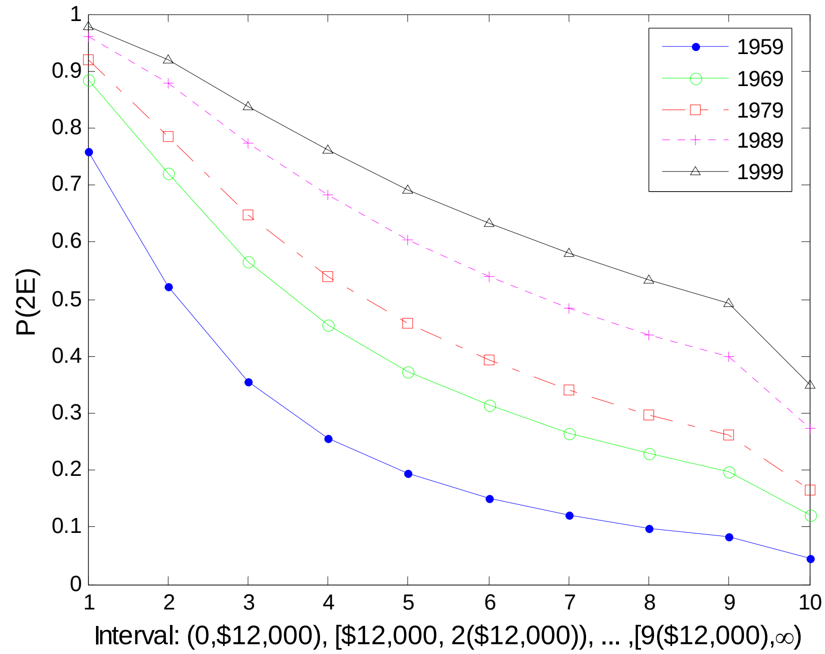

Figure 10: Model Exp 2: P(2E) by Interval of Husband's Real Labor Income / Average

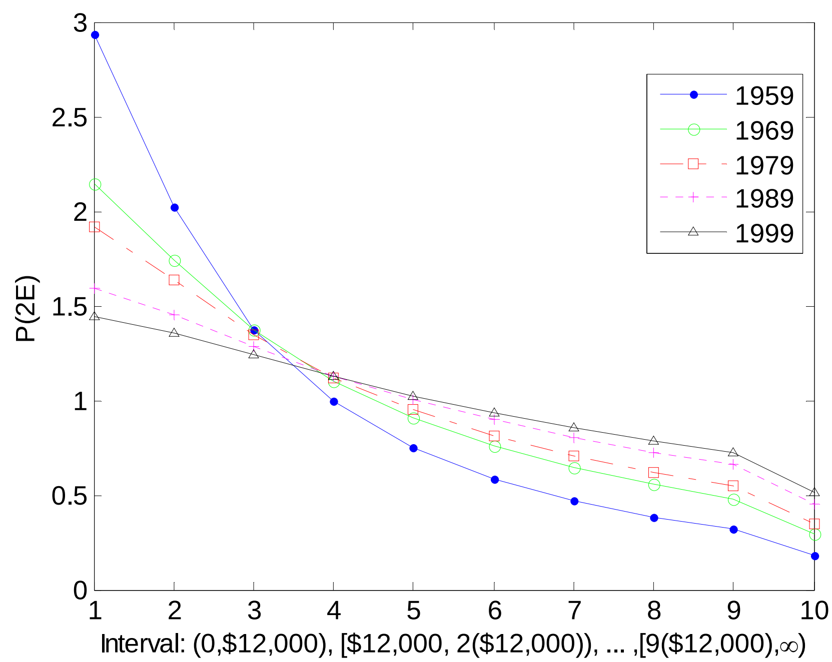

Figure 11: Model Exp 3: P(2E) by Interval of Husband's Real Labor Income

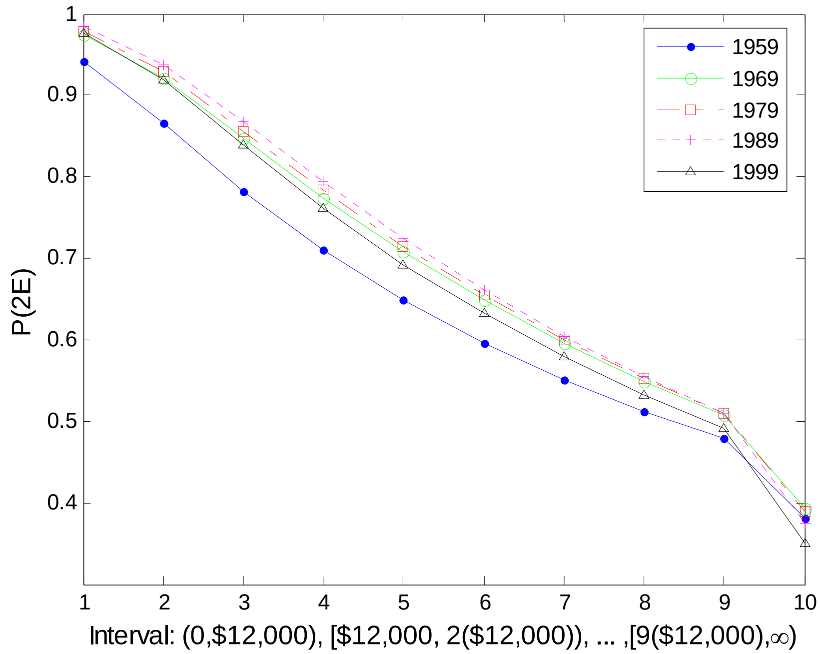

Figure 12: Model Exp 3: P(2E) by Interval of Husband's Real Labor Income / Average

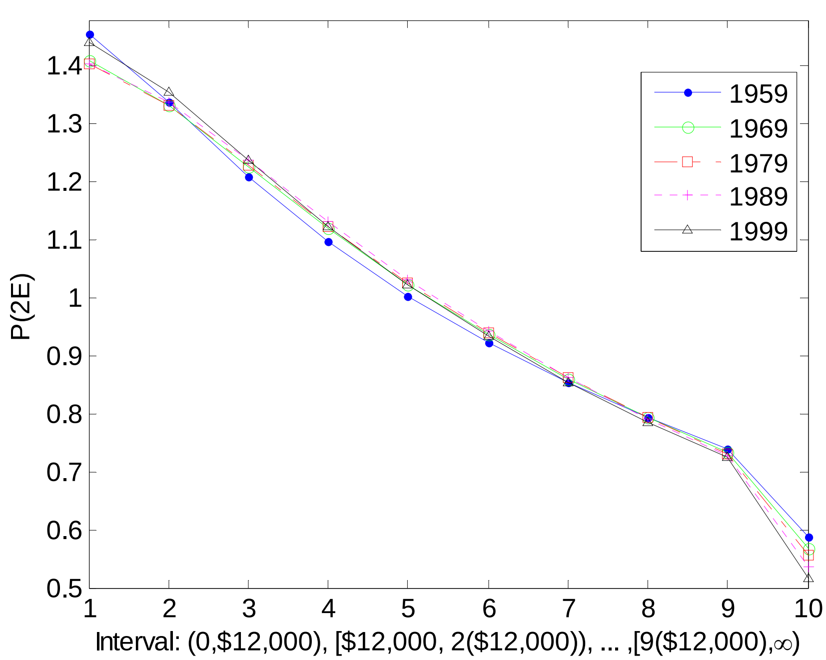

Figure 13: Model Exp 4: P(2E) by Interval of Husband's Real Labor Income

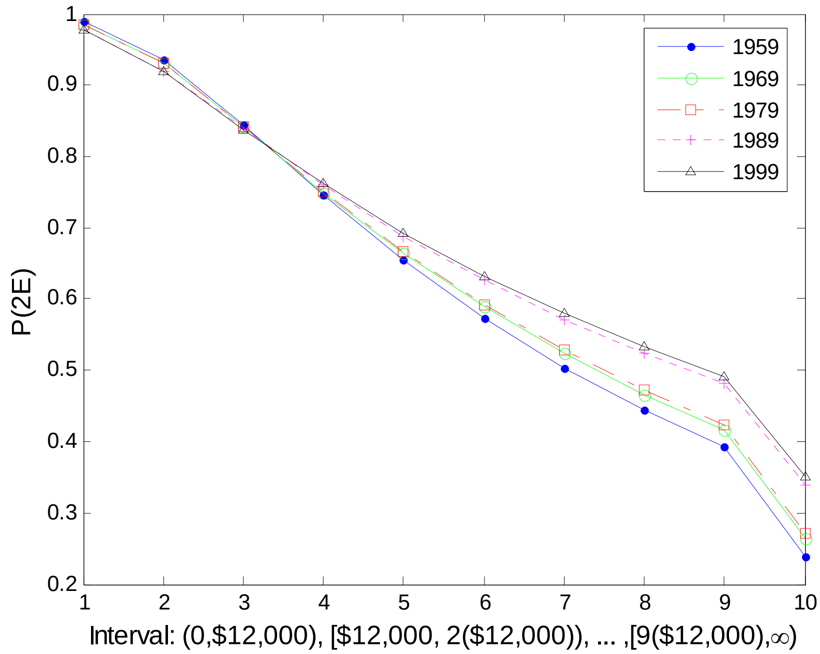

Figure 14: Model Exp 4: P(2E) by Interval of Husband's Real Labor Income / Average

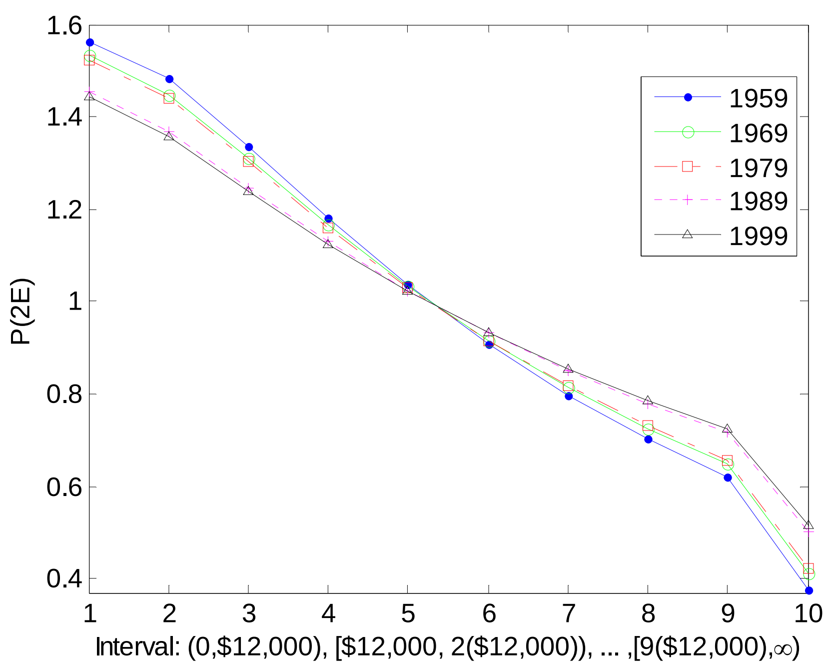

Figure 15: Model Exp 5: P(2E) by Interval of Husband's Real Labor Income

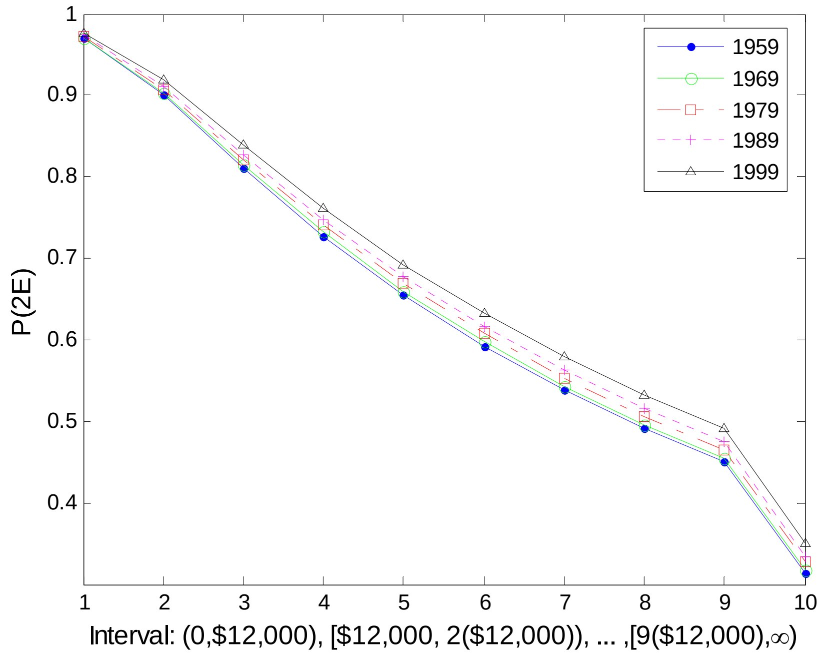

Figure 16: Model Exp 5: P(2E) by Interval of Husband's Real Labor Income / Average

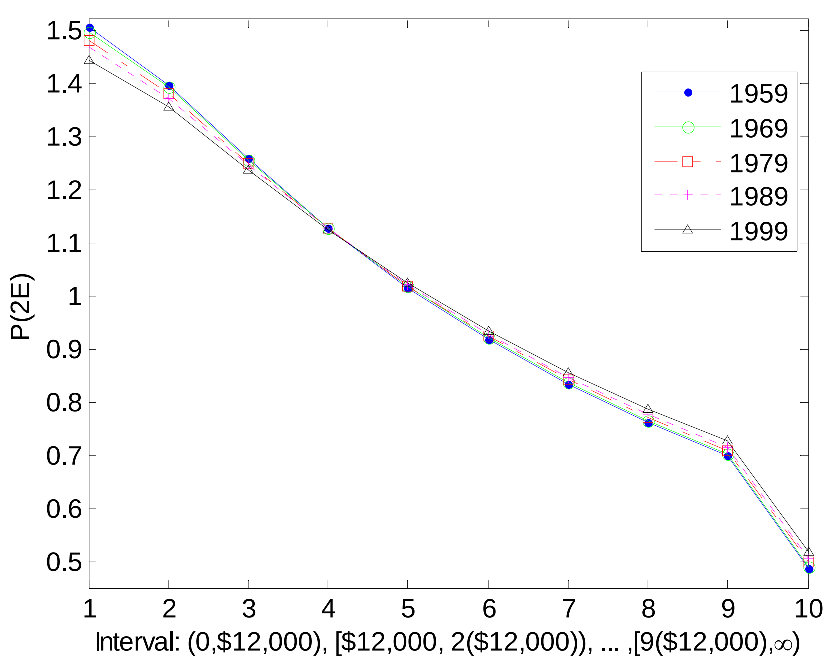

Figure 17: Model: Average Leisure$_f$ = Average Leisure$_m$, 2E couples

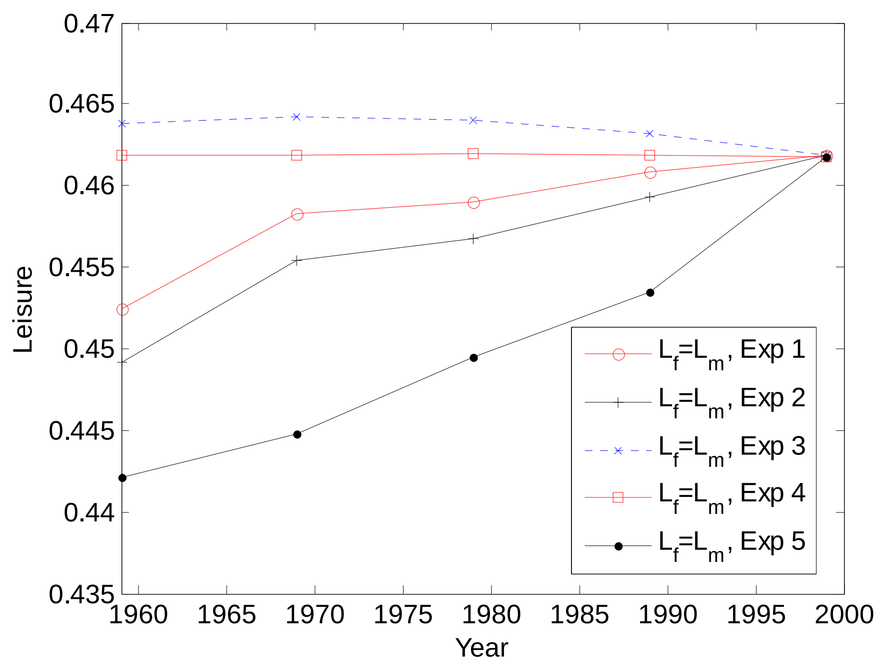

Figure 18: Model: Average Leisure$_m$, 1M couples

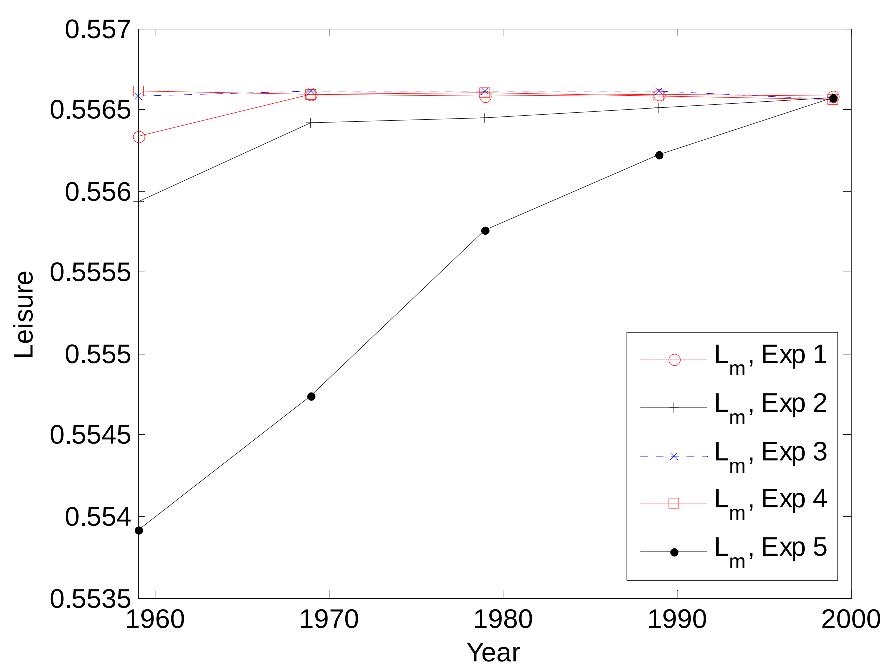

Figure 19: Model: Average Leisure$_f$, 1M couples

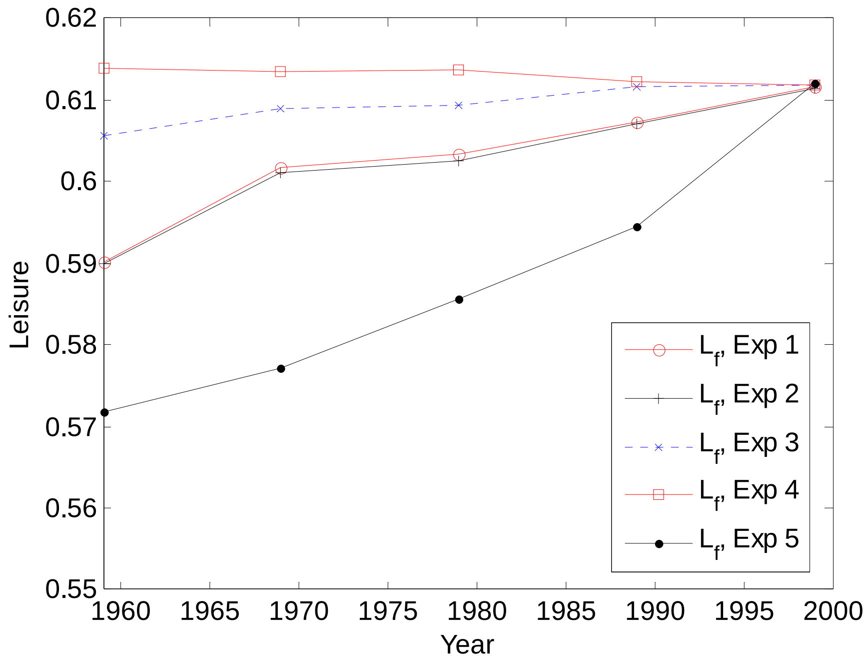

Figure 20: Model: Average Leisure$_m$ / Average Leisure$_f$, 1M couples

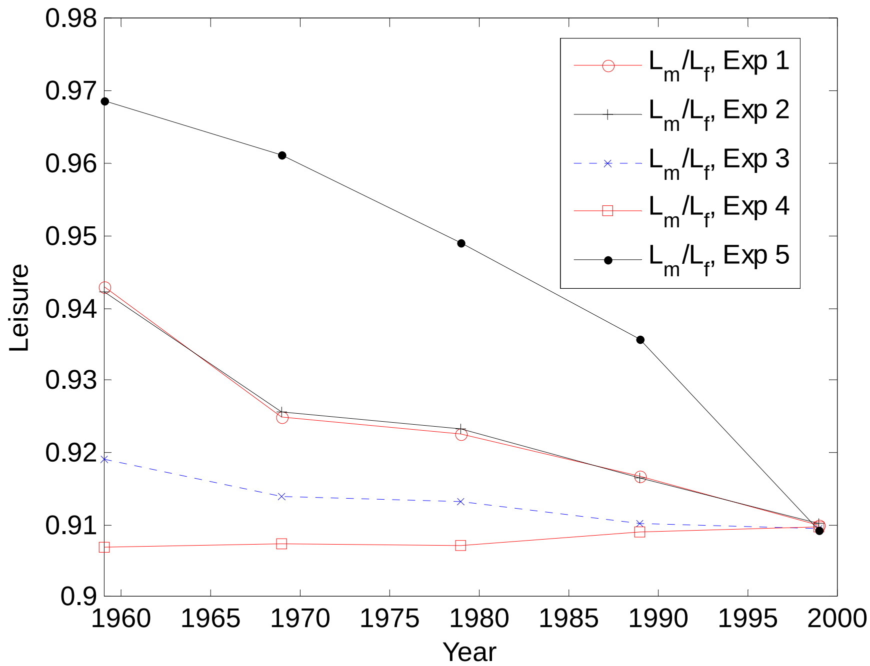

Figure 21: Model: Average Male Leisure

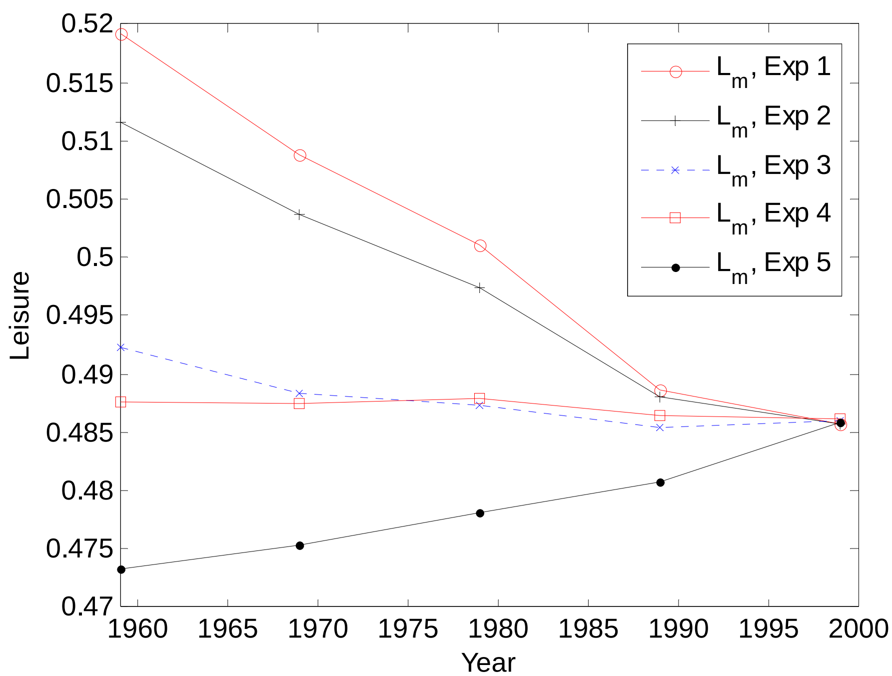

Figure 22: Model: Average Female Leisure

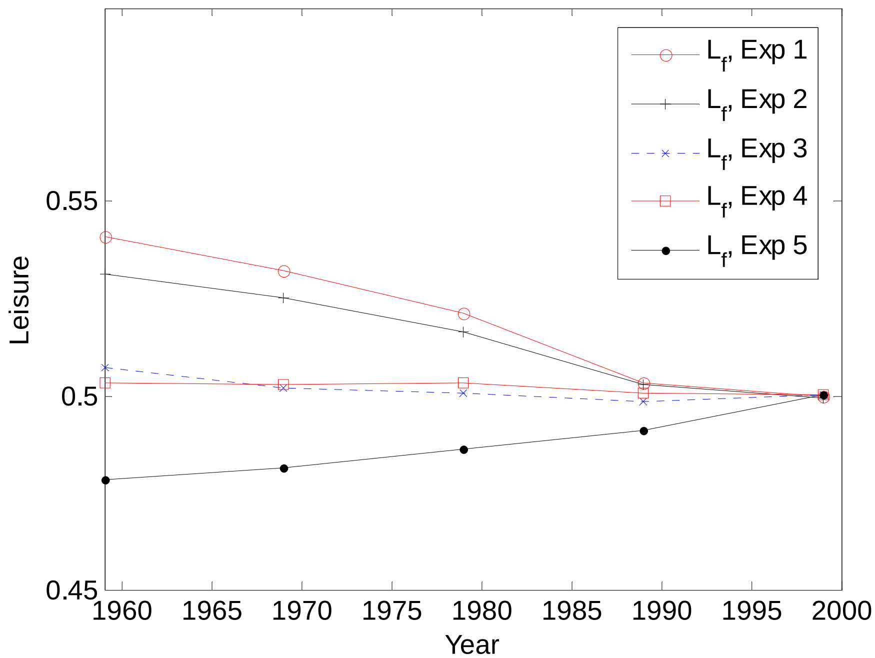

Figure 23: Model: Average Male Leisure / Average Female Leisure