Heterogeneous Couples, Household Interactions and Labor Supply Elasticities of Married Women*

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November, 2013

Abstract

This paper estimates labor supply elasticities of married women and men allowing for heterogeneity among couples (in educational attainments of husbands and wives) and explicitly modeling how household members interact and make their labor supply decisions. We find that the labor supply decisions of husbands and wives are interdependent unless both spouses are highly educated (college or above). The labor supply decisions of highly educated couples are jointly determined only if they have pre-school age children. We also find that labor supply elasticities differ greatly between households. The participation own-wage elasticity is largest (0.77) for women with low education married to men with low education, and smallest (0.03) for women with high education married to men with low education. The participation own-wage elasticities for women with low education married to highly educated men and for women with high education married to highly educated men are similar and fall between these two extremes (about 0.30 for each). The participation cross-wage elasticity of married women is relatively small (less than -0.05) if they are married to men with low education and larger (-0.37) if they are married to highly educated men. For all types of couples, participation non-labor family income elasticity is small. Allowing for heterogeneity across couples yields an aggregate participation own-wage elasticity of 0.56, a cross-wage elasticity of -0.13 and an income elasticity of -0.006 for married women. The analysis in this paper provides a natural framework to study how changes in educational attainments and household structure affect aggregate labor supply elasticities.

Keywords: Labor supply elasticity, family labor supply, household interactions, educational homogamy.
JEL Classification: J22, D10, C30.

*I owe a debt of gratitude to Nezih Guner and Joseph Hotz for detailed comments and help. I would like to thank Arnaud Maurel, Gabrielle Fack, Joan Llull, Manuel Arellano, Matt Delventhal, Pau Pujolàs, Richard Blundell, Thomas Lemieux, and Virginia Sánchez Marcos for valuable suggestions. I also benefited greatly from discussions with seminar participants at the Labor Lunch Seminar at Duke University and at Universitat Autònoma de Barcelona. The usual disclaimers apply.

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1 Introduction

Estimates of labor supply elasticities have a central place in empirical research in labor economics.[1] This is not surprising given the key role labor supply elasticities play in policy analysis (e.g. taxation) and in models of macroeconomic fluctuations.[2] With few notable exceptions, e.g. Lundberg (1988), however, the empirical literature studies labor supply elasticities of males or females without allowing for the possibility that husbands' and wives' labor supply decisions affect each other. Furthermore, labor supply elasticities are usually estimated for males or females as a group, and as a result labor supply decisions, and hence labor supply elasticities, depend neither on educational attainment of females nor on the relative education levels of husbands and wives (i.e. who is married to whom).

While there are few empirical studies on labor supply elasticities which contemplate interactions between household members, there is, on the other hand, a growing theoretical and empirical literature on household decision-making which emphasizes the importance of modeling households as a collection of individuals, each with his or her own utility function. The conventional unitary model, which considers the family as a single decision unit, has received little empirical support and its theoretical foundations have been questioned.[3] Several papers have proposed alternative models of the family labor supply decision to incorporate the preferences of different individuals living in the same household and to explain the interaction between family members. The alternative models include the cooperative bargaining models suggested by Manser and Brown (1980) and McElroy and Horney (1981), collective approach proposed by Chiappori (1988, 1992) and non-cooperative models developed by Konrad and Lommerud (1995).

In this paper, we estimate labor supply elasticities of married women and men allowing for heterogeneity between couples in terms of educational attainment and modeling explicitly how household members interact and make their labor supply decisions. Our questions are: How do husbands and wives interact when they decide their labor supply? Do families differ in the way they make their labor supply decisions? How do these differences affect labor supply elasticities of different households?

We focus on the static labor supply decisions of couples along the extensive margin. Couples differ in the education levels of husbands and wives, as well as in the way

[1] Blundell and MaCurdy (1999) and Keane (2011) provide extensive surveys of this literature.
[2] See, Chetty, Guren, Manoli and Weber (2011), Keane (2011) and Keane and Rogerson (2012).
[3] For a more detailed discussion see Lundberg and Pollak (1997).

they make their labor supply decisions. In particular, we consider two educational categories: less than college and college graduates and above, corresponding to low and high education. As there are two spouses, we distinguish four types of couples: (i) husband and wife with low education (homogamy-low) (ii) husband with high education and wife with low education (heterogamy-husband high) (iii) husband with low education and wife with high education (heterogamy-wife high), and (iv) husband and wife with high education (homogamy-high). Now that we have moved away from the standard unitary model and allow for the interaction between husbands and wives to affect the labor supply decision of each, we need to specify the way that these separate decisions are made. We consider five models of household decision-making behavior: (i) a model without interactions between spouses' decisions, (ii) a non-cooperative Nash model, (iii) a Stackelberg model with the husband as the leader, (iv) a Stackelberg model with the wife as the leader, and (v) a mixed model of Pareto-optimality and Nash equilibrium. Using data from the 2000 U.S. Census, we estimate the parameters of each of these models for each type of household using a maximum likelihood estimation strategy. Then, given the parameter estimates, we select the model that best predicts the observed labor supply behavior of a particular couple in the sample. As a result, for each type of household, we know the fraction of couples that is observed as following a particular decision-making process. Once we assign a particular decision-making process to each household, we calculate labor supply elasticities for household members.

Our results show that there is considerable variation among different couples in the way they make their labor supply decisions. In particular, the labor supply decisions of husbands and wives exhibit strong interactions unless both of the spouses have a high level of education. For more than 48% of homogamy-low and heterogamy couples, the joint labor supply decisions of husbands and wives are most consistent with the Stackelberg-wife leader game, whereas the decisions of 20% of these couples are best predicted by the Nash/Pareto optimality model. For homogamy-high couples, on the other hand, more than 45% of household decisions can be justified as coming from a model without interactions between spouses and more than 26% of household decisions are best explained as the result of a Nash game. When we also consider the presence of children, we find that labor supply decisions of spouses are more likely to be independent of each other if there are no children of pre-school age in the household. The presence of children matters most for homogamy-high couples. While without children we do not observe any interactions for a majority of households, with children the majority of household employment decisions are consistent with a non-cooperative

Nash game.

Apart from the observed variation in decision-making processes across different types of couples, we also observe that labor supply elasticities of married women of different types vary to a great extent. The participation own-wage elasticity is largest (0.77) for women with low education married to men with low education, and smallest (0.03) for highly educated women married to men with low education. The own-wage elasticities of women with low education married to highly educated men and for women with high education married to highly educated men are similar and fall between these two extremes (about 0.30). We also find that participation cross-wage elasticities for married women are relatively small (less than -0.05) if they are married to men with low education and larger (-0.37) if they are married to men with high education. For all types of couples, the participation non-labor family income elasticity is small.

Allowing for heterogeneity across couples yields an aggregate participation wage elasticity of 0.56, a cross-wage elasticity of -0.13 and an income elasticity of -0.006 for married women. Our participation own-wage elasticity estimate is larger than the recent estimates of labor supply elasticities of married women (e.g. Blau and Kahn, 2007; Heim, 2007).[4] The current analysis differs from these studies in that we allow for household interactions and we let these interactions differ across different types of households. Our analysis shows that ignoring the heterogeneity between household types and differences between couples in the way they make their labor supply decisions generate a lower labor supply wage elasticity for married women (0.20–0.29). We find that even if differences between couples in the way they make their labor supply decisions are ignored, accounting for the differences between household types already yields a higher labor participation wage elasticity for married women (0.46–0.49).

The results of this study have important implications for policy analysis. Since many policies are designed to target specific groups, it is essential to understand the potential differential impact on the labor supply of individuals. For instance, U.S. income transfer and tax policies — such as the Earned Income Tax Credit (EITC) or Temporary Assistance for Needy Families (TANF) programs — are targeted to encourage work among low–income families or families with children.[5] The differences in labor supply

[4]Heim (2007) shows that married women's participation wage elasticity declined from 0.66 to 0.03 between 1979 and 2003 in the U.S. Blau and Kahn (2007) find that participation own-wage elasticity of married women fell from 0.53–0.61 in 1980, to 0.41–0.44 in 1990, and to only 0.27–0.30 by 2000.

[5]Since estimates of labor supply elasticities are of key interest to policymakers, a substantial macroeconomic literature concerned about modeling labor supply decision of married men and women to study optimal taxation policies. Recent examples of this literature includes Alesina, Ichino, and Karabarbounis (2011) and Guner, Kaygusuz and Ventura (2012).

elasticities of married women depending on spouses' education levels is a dimension that has been overlooked by the literature. Furthermore, while earlier studies have focused on heterogeneity arising from the presence of pre-school age children, e.g. Del Boca (1997), Lundberg (1988), we further show that the variation in the responses of married women depending on the spouses' education levels is present, independent of whether children are present in the household or not.

The variation in labor supply elasticities of married women raises a natural question: What is the impact of compositional changes in the population on women's overall labor supply elasticities? Over the past several decades there have been dramatic changes in the educational composition of the population in the U.S. Not only have the educational attainment levels of men and women increased, but also the similarity between husbands and wives in their educational attainment has increased substantially (Mare 1991; Pencavel 1998; Schwartz and Mare 2005).[6] In order to get an idea of the effect of these compositional changes on married women's labor supply responsiveness, we carry out a counterfactual exercise. We calculate what the overall labor supply elasticities would be if married women had the responsiveness of 2000 but the distribution of couples would have been that of 1980s. We find a participation own-wage elasticity of 0.63, a participation cross-wage elasticity of -0.11 and a participation non-labor income elasticity of -0.004. This implies that, although compositional changes do not have a considerable effect on the participation cross-wage and participation non-labor income elasticities of married women, the changing composition of couples accounts for a decline in participation own-wage elasticity of married women — from 0.63 to 0.56 — between 1980 and 2000.

This paper is related to three strands of literature. First, it is naturally related to the large empirical literature that provides empirical estimates of labor supply elasticities for married women. Heim (2007) and Blau and Kahn (2007) are recent examples of papers in this group. Both studies find a decline in women's labor supply elasticities over the past several decades. The decline in the labor supply elasticities of married women has been attributed to the increase in marriage instability and increasing work opportunities for women (Goldin, 1990; Blau and Kahn, 2007). However, marriage instability and the work opportunities available to women depend on their educational

[6] Greenwood, Guner, Kocharkov, and Santos (2012) develop a model of marriage, divorce, educational attainment and married female labor-force participation to understand the increase in assortative mating, as well as the differential fall in marriage and rise in divorce for individuals with different levels of educational attainment in the U.S. They show that technological progress in the household sector and changes in the wage structure are important for explaining these facts.

attainment and also their educational similarity with their spouses.[7] Since factors that might affect the labor supply responsiveness of married women differ by the level of educational attainment as well as the educational similarity of spouses, it is natural to think that labor supply responsiveness does so as well. In addition, Heim (2007) and Blau and Kahn (2007) abstract from the interactions between household members.

There are a few empirical studies which have estimated joint labor supply of husbands and wives as opposed to individual labor supply, such as Apps and Rees (1996), Blundell, Chiappori, Magnac and Meghir (2007), Chiappori, Fortin and Lacroix (2002), Fortin and Lacroix (1997), Hausmand and Ruud (1984), Kooreman and Kapteyn (1990), and Ransom (1987a, 1987b). Hausman and Ruud (1984), and Ransom (1987a, 1987b) account for the interdependent nature of family labor supply decisions in a unitary framework. On the other hand, Apps and Rees (1996), Blundell, Chiappori, Magnac and Meghir (2007), Chiappori, Fortin and Lacroix (2002), Fortin and Lacroix (1997), and Kooreman and Kapteyn (1990) test the unitary model and find that restrictions implied by the unitary framework are rejected by the data. As a further step, these studies estimate the labor supply equations of husbands and wives from a collective specification. However, all these studies assume that within-household allocations are efficient for all couples. Del Boca (1997) and Lundberg (1988) also test alternative theories of family labor supply behavior. Additionally, they consider the possibility that couples are heterogeneous in the way that they make their labor supply decisions. However, both studies consider the presence of young children as the only source of heterogeneity, former between Italian couples, and the later between low income families in the U.S. In this paper, we consider the heterogeneity in educational attainments of husbands and wives and show that the variation in the responses of married women depending on the spouses' education levels is present, independent of whether children are present in the household or not.

Second, this paper is related to the literature that studies household interactions. The models that we employ to estimate the labor supply elasticity of women are include both non-cooperative and cooperative models. In non-cooperative models, as developed by Konrad and Lommerud (1995), each individual within a household maximizes

[7]Earlier studies show that women with high education have lower marital dissolution rates than other women (Bumpass, Martin and Sweet, 1991; Martin, 2006). Moreover, the marriage instability is higher for couples with dissimilar education levels than couples with similar education levels (Martin, 2006; Tzeng, 1992). The direction and the magnitude of the effect depend on which spouse is more educated (Bitter, 1986; Bumpass, Martin and Sweet, 1991). On the other hand, highly educated women have gained the most in terms of labor market opportunities, and labor force gains have been largest for wives married to highly educated and high-earning husbands (Cohen and Bianchi, 1998; Juhn and Murphy, 1997).

his or her own utility, relative to his or her own budget constraint, taking the actions of other household members as given. The cooperative approach includes collective models developed by Chiappori (1988, 1992), as well as cooperative bargaining models suggested by Manser and Brown (1980) and McElroy and Horney (1981). The collective approach assumes that household decisions are Pareto-efficient. Cooperative bargaining models, which are a particular case of collective models, represent household allocations as the outcome of some specific bargaining process and the cooperative allocation reached depends crucially on the threat point, i.e. what happens in case of disagreement among couples.[8] Following the literature that studies household interactions, we consider alternative equilibrium concepts, including the non-cooperative Nash game and Stackelberg leader game, and the approach which imposes Pareto optimality on the observed decisions of husbands and wives. However, we do not impose the restriction that all couples decide their labor supply in the same way and allow for the possibility that husband-wife interactions may differ across couples.

Finally, our paper is related to recent papers in the empirical labor literature that allow for heterogeneity in household decision-making or household interactions. Jia (2005) analyzes the labor supply decision of retiring couples in Norway and assumes that there are two types of families, cooperative and non-cooperative. Her results show that more than half of the households are of the non-cooperative type. Similarly, Eckstein and Lifshitz (2012) considers two type of families while modeling the labor supply of husbands and wives, modern and classical. They assume that classical household follows a Stackelberg leader game in which the wife's labor supply decision follows her husband's already-known employment outcome, while the modern family plays a Nash game. They estimate that 38% of families are of the modern type and the participation rate of women in those households is almost 80%. Differing from Eckstein and Lifshitz (2012), we consider the education level and relative education levels of spouses as the source of heterogeneity. In addition we do not assume a certain structure of the decision-making a priori.

The remainder of the paper is organized as follows. The next section describes the family labor supply models that are employed in our analysis. Section 3 discusses the identification issues and explains the estimation strategy. Section 4 presents the data source and the empirical specification. The main estimation results for the family labor supply models and labor supply elasticities of married women are presented in Section

[8] Manser and Brown (1980) and McElroy and Horney (1981) use divorce as the threat point while Lundberg and Pollak (1993), Haddad and Kanbur (1994), Konrad and Lommerud (2000) and Chen and Woolley (2001) use some form of non-cooperative behavior as the threat point.

5. Finally, Section 6 discusses the role of changes in the educational composition of the population composition on declining labor supply elasticities of married women and Section 7 concludes.

2 Modeling Family Labor Supply

We focus on the static labor supply decisions of husbands and wives along the extensive margin. To this end, let y_h and y_w be the participation decisions of the husband and the wife, respectively. These decisions are defined as

$$y_h = \begin{cases} 1 \text{ if the husband works} \\ 0 \text{ otherwise} \end{cases} \quad \text{and} \quad y_w = \begin{cases} 1 \text{ if the wife works} \\ 0 \text{ otherwise.} \end{cases}$$

Since there are two individuals and two possible actions for each of the spouse, there are four possible outcomes of the family labor supply decision, (y_h, y_w): (i) both spouses work, (ii) only husband works, (iii) only wife works, or (iv) both spouses do not work. We assume that each spouse maximizes his or her utility. However, the decisions of husbands and wives are interdependent, such that each individual's employment decision is affected by his or her spouse's decision. Let $U_h(y_h, y_w)$ denote the husband's utility of taking action y_h if his wife takes action y_w, and $U_w(y_h, y_w)$ be the wife's utility of taking action y_w if her husband takes action y_h. Following McFadden (1974, 1981) the individual utilities, $U_h(y_h, y_w)$ and $U_w(y_h, y_w)$, are treated as random and decomposed into deterministic and random components. Assumption A.1 states this formally:

Assumption A.1

$$\begin{aligned} U_h(y_h, y_w) &= V_h(y_h, y_w) + \eta_h(y_h, y_w) \\ U_w(y_h, y_w) &= V_w(y_h, y_w) + \eta_w(y_h, y_w), \end{aligned}$$

where for $i = h, w$, $V_i(y_h, y_w)$ is the deterministic component and $\eta_i(y_h, y_w)$ is the random component of the individual utility. Furthermore, we make the following simplifying assumption on random components:

Assumption A.2 For a given labor supply decision of the spouse, y_i for $i = h, w$,

$$\begin{aligned} \eta_h(1, y_w) - \eta_h(0, y_w) = \eta_h^1 - \eta_h^0 &= \varepsilon_h \\ \eta_w(y_h, 1) - \eta_w(y_h, 0) = \eta_w^1 - \eta_w^0 &= \varepsilon_w, \end{aligned}$$

where $(\varepsilon_h, \varepsilon_w)$ are normally distributed with zero means, unit variances and correlation ρ. Assumption A.2 states that the random component of utility does not depend on the labor supply decision of the spouse. Hence, we allow for unobserved heterogeneity in utility derived from working through the ε_h and ε_w. Allowing ε_h and ε_w to be correlated reflects the fact that for a particular couple there may be common, unobserved factors affecting both spouses' utilities of working.

Finally, we assume that the change in individual's deterministic utility associated to a change in spouse's action is constant. This is summarized by the following assumption:

Assumption A.3

$$\begin{aligned} V_h(1,1) - V_h(1,0) &= \alpha_h^1 \quad V_w(1,1) - V_w(1,0) = \alpha_w^1 \\ V_h(0,1) - V_h(0,0) &= \alpha_h^0 \quad V_w(0,1) - V_w(0,0) = \alpha_w^0 \end{aligned}$$

Combined with Assumption A.2, this implies that the change in an individual's overall utility associated with a change in their spouse's action is also constant. In other words, we rule out the second order effects of spouse's employment on individual's utility.

For empirical implementation, the deterministic component of an individual's utility is assumed to be a linear function of individual's observable characteristics, x_h and x_w. Hence, together with assumptions A.1 to A.3, the model is parametrized as

$$\begin{aligned} U_h(1,1) &= x_h'\beta_h^1 + \alpha_h^1 + \eta_h^1 \quad U_w(1,1) = x_w'\beta_w^1 + \alpha_w^1 + \eta_w^1 \\ U_h(0,1) &= x_h'\beta_h^0 + \alpha_h^0 + \eta_h^0 \quad U_w(1,0) = x_w'\beta_w^0 + \alpha_w^0 + \eta_w^0 \\ U_h(1,0) &= x_h'\beta_h^1 \qquad\quad + \eta_h^1 \quad U_w(0,1) = x_w'\beta_w^1 \qquad\quad + \eta_w^1 \\ U_h(0,0) &= x_h'\beta_h^0 \qquad\quad + \eta_h^0 \quad U_w(0,0) = x_w'\beta_w^0 \qquad\quad + \eta_w^0. \end{aligned} \tag{1}$$

In the family labor supply model, the utility or the payoff of working can be interpreted as the market wage. The utility or the payoff of not working can be interpreted as the reservation wage of the individual.

For example, consider the wife's decision whether to work or not, i.e. $y_w \in \{0,1\}$. For $y_w = 1$, $U_h(0,1)$ denotes the reservation wage of the husband when his wife works. Similarly, for $y_w = 0$, $U_h(0,0)$ is his reservation wage when the wife does not work. Hence, $U_h(0,1) - U_h(0,0) = \alpha_h^0$ captures the impact of the wife's employment on the husband's reservation wage. On the other hand, for $y_w = 1$, $U_h(1,1)$ is the market wage of the husband when his wife works. When the wife does not work, i.e. $y_w = 0$, $U_h(1,0)$ gives the market wage of the husband. Note that $U_h(1,1) - U_h(1,0) = \alpha_h^1$ is the effect of the wife's employment on the husband's reservation wage. For the wife, the wage equations are written analogously.

Although, economic theory suggests that the spouse's employment would affect an individual's reservation wage but not his or her market wage, one can test the presence of both effects by including α_i^0 and α_i^1 (for $i = h, w$) in the model and testing the significance of these parameters. Therefor, we include the impact of the spouse's employment decision on the individual's market wage (α_h^1 and α_w^1) in the model without imposing the restriction that the effect is zero.

To complete the family labor supply model, it is crucial to determine how the observed dichotomous variables y_h and y_w are generated. The simultaneous probit model is a natural choice to extend the single-person discrete choice model to accommodate the labor supply decisions of both spouses.[9] In the simultaneous probit model, the observed dichotomous variables (y_h and y_w) are assumed to be generated according to the following rule:

$$y_h = \begin{cases} 1 \; if \; y_h^* \geq 0 \\ 0 \; otherwise \end{cases} \text{ and } \; y_w = \begin{cases} 1 \; if \; y_w^* \geq 0 \\ 0 \; otherwise, \end{cases}$$

where

$$y_h^* = y_w[U_h(1,1) - U_h(0,1)] + (1 - y_w)[U_h(1,0) - U_h(0,0)],$$

and

$$y_w^* = y_h[U_w(1,1) - U_w(0,1)] + (1 - y_h)[U_w(1,0) - U_w(0,0)]. \tag{2}$$

Equation 2 states that, for a given employment decision of the spouse, an individual decides to work or not based on a simple utility comparison. Under assumptions A.1 to A.3, and model parametrization in Equation 1, it follows that

$$\begin{aligned} y_h^* &= x_h^{'}\beta_h + \alpha_h y_w + \varepsilon_h \\ y_w^* &= x_w^{'}\beta_w + \alpha_w y_h + \varepsilon_w, \end{aligned} \tag{3}$$

where $\beta_i^1 - \beta_i^0 = \beta_i$, $\alpha_i^1 - \alpha_i^0 = \alpha_i$ and $\eta_i^1 - \eta_i^0 = \varepsilon_i$ for $i = w, h$.

Given Equations 2 and 3, utility comparisons of the husband and the wife, and as a

[9]See Maddala (1974) for details.

result the probability of each of the four possible outcomes of the joint labor supply decision of a couple can be written as conditions on random components ε_h and ε_w, i.e. model parameters. For each possible outcome of the family labor supply decision, Table 1 presents conditions on the husband's and the wife's utility comparisons and conditions that must be satisfied by the random components.

Table 1: Conditions for observed outcomes in simultaneous probit model

Husband's and Wife's actions	Utility Comparison	Condition
$y_h = 1$ and $y_w = 1$	$U_h(1,1) > U_h(0,1)$ and $U_w(1,1) > U_w(1,0)$	$\varepsilon_h > -x_h^{'}\beta_h - max(0,\alpha_h)$ and $\varepsilon_w > -x_w^{'}\beta_w - max(0,\alpha_w)$
$y_h = 1$ and $y_w = 0$	$U_h(1,0) > U_h(0,0)$ and $U_w(1,1) < U_w(1,0)$	$\varepsilon_h > -x_h^{'}\beta_h - min(0,\alpha_h)$ and $\varepsilon_w < -x_w^{'}\beta_w - max(0,\alpha_w)$
$y_h = 0$ and $y_w = 1$	$U_h(1,1) < U_h(0,1)$ and $U_w(0,1) > U_w(0,0)$	$\varepsilon_h < -x_h^{'}\beta_h - max(0,\alpha_h)$ and $\varepsilon_w > -x_w^{'}\beta_w - min(0,\alpha_w)$
$y_h = 0$ and $y_w = 0$	$U_h(1,0) < U_h(0,0)$ and $U_w(0,1) < U_w(0,0)$	$\varepsilon_h < -x_h^{'}\beta_h - min(0,\alpha_h)$ and $\varepsilon_w < -x_w^{'}\beta_w - min(0,\alpha_w)$

For example, for a given employment decision of the wife y_w, the husband works if his utility of working, $U_h(1, y_w)$, is greater than his utility of not working, $U_h(0, y_w)$. Similarly, the wife works based on the comparison between $U_w(1, y_w)$ and $U_w(0, y_w)$ for a given employment decision of her husband y_h. Hence, for a particular couple, the probability that both spouses work, i.e. $(y_h, y_w) = (1, 1)$, equals the probability that $U_h(1, 1) > U_h(0, 1)$ and $U_w(1, 1) > U_w(1, 0)$. However, the utility comparisons, $U_h(1, 1) > U_h(0, 1)$ and $U_w(1, 1) > U_w(1, 0)$ can only arise if certain conditions on the random components ε_h and ε_w are satisfied. In particular, $U_h(1, 1) > U_h(0, 1)$ and $U_w(1, 1) > U_w(1, 0)$ will only hold if $\varepsilon_h > -x_h^{'}\beta_h - max(0, \alpha_h)$ and $\varepsilon_w > -x_w^{'}\beta_w - max(0, \alpha_w)$. Hence, the probability that both spouses work, i.e. $(y_h, y_w) = (1, 1)$ equals to the probability that $\varepsilon_h > -x_h^{'}\beta_h - max(0, \alpha_h)$ and $\varepsilon_w > -x_w^{'}\beta_w - max(0, \alpha_w)$.

The multiple-person choice model differs from the single-person model in that it allow for the possibility of simultaneity between individuals' decisions (Bresnahan and Reiss, 1991). A well known difficulty with the simultaneous probit model is that the relationship between $(\varepsilon_h, \varepsilon_w)$ and (y_h, y_w) defined by the model is not one to one. In particular, the sum of the probabilities of observed outcomes either exceeds one or is less than one depending on the sign of the $\alpha_h \times \alpha_w$. This means that, the model described in Equation 3 is *incoherent* and *incomplete.*[10] For instance, if $\alpha_h \times \alpha_w \geq 0$, there is a region $R \subset \varepsilon_h \times \varepsilon_w$, where the model delivers multiple solutions for y_h and y_w for the same set of parameter values, i.e. the model is *incomplete.* Hence, the sum of the probabilities of four mutually exclusive possible outcomes — $(1,1)$,$(1,0)$,$(0,1)$ and $(0,0)$ — exceeds one. On the other hand, if $\alpha_h \times \alpha_w < 0$, the model is *incoherent* for the region $R \subset \varepsilon_h \times \varepsilon_w$, i.e. there is no solution for y_h and y_w. In this case, the sum of the probabilities of possible outcomes is less than one.

In order for the simultaneous probit model to be coherent, one needs to impose the coherency condition $\alpha_h \times \alpha_w = 0$ (Heckman, 1978). However, imposing the parameter restriction $\alpha_h \times \alpha_w = 0$ essentially eliminates the simultaneity from the model, which is crucial for allowing the possibility that husband's and wife's labor supply decisions affect each other. To consider the interdependence of husband's and wife's employment decisions, an alternative is to impose more structure to the model. The models developed by Bjorn and Vuong (1984, 1985) and Kooreman (1994) ensure completeness and coherence of the model without imposing $\alpha_h \times \alpha_w = 0$. In this setting, instead of the rule described in Equation 2, the observed dichotomous variables y_h and y_w are assumed to be the outcomes of a static discrete game played between two agents.

Bjorn and Vuong (1984) use the non-cooperative Nash concept and assume that the observed dichotomous variables are the pure-strategy Nash equilibrium outcomes of a game played between agents. Bjorn and Vuong (1985) propose a similar game theoretical model using the Stackelberg equilibrium concept. Since game theoretical models may yield outcomes that are not Pareto optimal, Kooreman (1994) suggests an alternative approach that is based on the Nash principle but ensures that the outcome is always Pareto optimal. In our analysis, we employ the game theoretical models suggested by Bjorn and Vuong (1984, 1985) and Kooreman (1994) in addition to the simultaneous probit model by imposing the coherency condition, $\alpha_h = \alpha_w = 0$. We compare these game theoretical models, which allow for the interdependence of the employment decisions of the husband and the wife, with the simultaneous probit model where the coherency restriction is imposed.

2.1 Nash Model

In the Nash game, the husband and the wife decide their labor supply simultaneously. Hence, each possible decision of the spouse leads to a reaction function for the in-

[10]See Figure A.1. of Appendix A for details.

dividual. Since there are four possible outcomes of the game each spouse has four possible reaction functions. These reaction functions are (i) always decide not to work (ii) always take the same action as the spouse (iii) always take the opposite action of the spouse, and (iv) always decide to work. As the roles of the spouses in this game are symmetric, the reaction functions of the husband and the wife are identical. We denote the reaction functions of the husband with H_1, H_2, H_3 and H_4, and the reaction functions of the wife with W_1, W_2, W_3 and W_4. The reaction functions for the husband and the wife are summarized in the first column of Table 2 and Table 3, respectively.

Table 2: Husband's reaction functions

Reaction function	Utility Comparison	Condition
H_1: $y_h = 0$ if $y_w = 0$ and $y_h = 0$ if $y_w = 1$	$U_h(1,0) < U_h(0,0)$ and $U_h(1,1) < U_h(0,1)$	$\varepsilon_h < -x_h'\beta_h - max(0, \alpha_h)$
H_2: $y_h = 0$ if $y_w = 0$ and $y_h = 1$ if $y_w = 1$	$U_h(1,0) < U_h(0,0)$ and $U_h(1,1) > U_h(0,1)$	$-x_h'\beta_h - \alpha_h < \varepsilon_h < -x_h'\beta_h$ if $\alpha_h \geq 0$
H_3: $y_h = 1$ if $y_w = 0$ and $y_h = 0$ if $y_w = 1$	$U_h(1,0) > U_h(0,0)$ and $U_h(1,1) < U_h(0,1)$	$-x_h'\beta_h < \varepsilon_h < -x_h'\beta_h - \alpha_h$ if $\alpha_h < 0$
H_4: $y_h = 1$ if $y_w = 0$ and $y_h = 1$ if $y_w = 1$	$U_h(1,0) > U_h(0,0)$ and $U_h(1,1) > U_h(0,1)$	$\varepsilon_h > -x_h'\beta_h - \min(0, \alpha_h)$

Each reaction function for an individual will arise, i.e. will be the best response, if certain conditions on utility comparisons hold. The second column of Table 2 and Table 3 summarize the utility comparisons of the husband and the wife for their corresponding reaction functions. Each utility comparison, however, can only arise if certain conditions for the random components ε_h and ε_w are satisfied. We use the model parametrization in Equation 1 to determine the conditions on the random components that must be satisfied for each reaction function to arise. These conditions are provided in the third column of Tables 2 and 3.

For instance, the reaction function H_1 says that the husband always chooses not to work, whether the wife works or not (column 1 of Table 2). The reaction function H_1 arises if, for the husband, the utility of not working is greater than the utility of working for any decision of the wife, i.e. $U_h(1, y_w) < U_h(0, y_w)$ for $y_w = 0, 1$ (column 2 of Table 2). The corresponding condition on the random component ε_h for utility comparison $U_h(1,1) < U_h(0,1)$ and $U_h(1,0) < U_h(0,0)$ is $\varepsilon_h < -x_h'\beta_h - max(0, \alpha_h)$ (column 3 of Table 2).

Given the reaction functions of the husband and the wife, the Nash equilibrium in pure

Table 3: Wife's reaction functions

Reaction function	Utility Comparison	Condition
W_1: $y_w = 0$ if $y_h = 0$ and $y_w = 0$ if $y_h = 1$	$U_w(0,1) < U_w(0,0)$ and $U_w(1,1) < U_w(1,0)$	$\varepsilon_w < -x_w^{'}\beta_w - \max(0, \alpha_w)$
W_2: $y_w = 0$ if $y_h = 0$ and $y_w = 1$ if $y_h = 1$	$U_w(0,1) < U_w(0,0)$ and $U_w(1,1) > U_w(1,0)$	$-x_w^{'}\beta_w - \alpha_w < \varepsilon_w < -x_w^{'}\beta_w$ if $\alpha_w > 0$
W_3: $y_w = 1$ if $y_h = 0$ and $y_w = 0$ if $y_h = 1$	$U_w(0,1) > U_w(0,0)$ and $U_w(1,1) < U_w(1,0)$	$-x_w^{'}\beta_w < \varepsilon_w < -x_w^{'}\beta_w - \alpha_w$ if $\alpha_w < 0$
W_4: $y_w = 1$ if $y_h = 0$ and $y_w = 1$ if $y_h = 1$	$U_w(0,1) > U_w(0,0)$ and $U_w(1,1) > U_w(1,0)$	$\varepsilon_w > -x_w^{'}\beta_w - \min(0, \alpha_w)$

strategies (hereafter NE) can be defined.[11] Table 4 presents the NE for each of the pairs of reaction functions. For instance, for the pair (H_1, W_4), there is a unique NE, that is (0,1), i.e. husband chooses not to work and wife chooses to work. As seen in Table 4, in some cases, there are multiple Nash equilibria and in others, there is no NE in pure strategies.

Once again, existence of multiple Nash equilibria and no NE in pure strategies correspond to the *incompleteness* and *incoherency* of the model. In order to ensure coherence and completeness, we follow the approach proposed by Bjorn and Vuong (1984) and include an equilibrium selection mechanism to the model.[12] Modeling the equilibrium selection mechanism requires additional assumptions, however, it does not require eliminating the simultaneity from the model as required by the simultaneous probit model.

We include the equilibrium selection mechanism to the model following the approach suggested by Bjorn and Vuong (1984). We assume that each equilibrium has an equal probability to be chosen by the couple when there are multiple equilibria.[13] In case of no Nash equilibrium, the couple is assumed to choose from one of the possible alternatives with equal probabilities.

[11] The equilibrium concept adopted here is Nash in pure strategies. For a similar approach, see applications by Bresnehan and Reiss (1990) for a firm entry model in automobile retail market, and by Bjorn and Vuong (1994) for a model of household labor supply. For a review of alternative equilibrium concepts see De Paula (2013).

[12] For alternative strategies to identify model parameters see Tamer (2003) and Ciliberto and Tamer (2009).

[13] Alternative equilibrium selection mechanisms are suggested by Bresnahan and Reiss (1990, 1991), who treat the multiple outcomes as one event. However, this approach limits the model predictability (Tamer, 2003).

Table 4: Nash Equilibria in pure strategies

Husband/Wife	W_1	W_2	W_3	W_4
H_1	(0,0)	(0,0)	(0,1)	(0,1)
H_2	(0,0)	(0,0) or (1,1)	No NE	(1,1)
H_3	(1,0)	No NE	(0,1) or (1,0)	(0,1)
H_4	(1,0)	(1,1)	(1,0)	(1,1)

For instance, the outcome $(y_h, y_w) = (0, 1)$, i.e. husband does not work and wife works, is the NE, if the pair of husband's and wife's reaction functions is (H_1, W_3), or (H_1, W_4), or (H_3, W_4). In addition, the NE of the game will be (0,1) with a probability 1/2 if the pair of husband's and wife's reaction functions is (H_3, W_3) and with a probability 1/4 if the pair of husband's and wife's reaction functions is (H_3, W_2).

Hence, the probability of the outcome $(y_h, y_w) = (0, 1)$ to be NE of the game can be written as the sum of probabilities of husband's and wife's reaction functions pairs. Given Tables 2 to 4, the probability of each of the four possible outcomes for the joint labor supply decision of a couple can be expressed in terms of conditions on the random components ε_h and ε_w, and therefore in terms of model parameters.[14]

2.2 Stackelberg Leader Model

The labor supply decision of couples can also be reformulated by using a different equilibrium concept, that of the Stackelberg-leader game. In this case, y_h and y_w are assumed to be the Stackelberg leader equilibrium (hereafter SE) outcomes of a sequential game. In this game, one of the players (the leader) moves first and then the other player (the follower) moves after observing the action of the leader. Hence, the roles of players are asymmetric. The leader is assumed to maximize his or her utility anticipating the reaction of the follower. In other words, the leader takes into account the payoff of the follower in making his or her decision. In the family labor supply, the roles of husband and wife are not known a priori, so we consider two versions of a Stackelberg leader game played between spouses: first, assuming that the husband is the Stackelberg leader, and second, assuming that the wife is the Stackelberg leader. In this section, we briefly explain the Stackelberg model assuming that the wife is the Stackelberg leader and her husband is the follower. The Stackelberg-husband leader

[14]See Appendix B for details.

model is analogous.[15]

In a Stackelberg-wife leader game, the wife takes into account the four possible reaction functions of her husband, H_1, H_2, H_3, and H_4 when she makes her decision. The reaction functions of the husband are the same as the ones in the Nash model, which are described in Table 2. As, in the Stackelberg-wife leader game the roles of the spouses are asymmetric, so each reaction function of the husband corresponds to a utility comparison for the wife. For each reaction function of the husband, the utility comparison of the wife, S_j for $j = 1, 2, 3, 4$ is given in Table 5. For example, if the wife knows that the husband always decides not to work, independently of her working or not, the corresponding utility comparison of the wife is S_1, i.e. the wife only works if $U_w(1,0) > U_w(0,0)$ and does not work if $U_w(1,0) < U_w(0,0)$. Once again, the utility comparisons of the wife can only arise if certain conditions are satisfied by ε_w. These conditions are provided in the last column of Table 5.

Table 5: Wife's utility comparisons

Reaction function for the husband	Utility comparison for the wife	Condition
H_1	S_1: $U_w(0,1) > U_w(0,0)$	$\varepsilon_w > -x_w^{'}\beta_w$
H_2	S_2: $U_w(1,1) > U_w(0,0)$	$\varepsilon_w > -x_w^{'}\beta_w - \alpha_w^1$
H_3	S_3: $U_w(0,1) > U_w(1,0)$	$\varepsilon_w > -x_w^{'}\beta_w - \alpha_w^0$
H_4	S_4: $U_w(1,1) > U_w(1,0)$	$\varepsilon_w > -x_w^{'}\beta_w - \alpha_w$

Table 6: Stackelberg Equilibria

H_1 and S_1	(0,1)	H_3 and S_3	(0,1)
H_1 and $\overline{S_1}$	(0,0)	H_3 and $\overline{S_3}$	(1,0)
H_2 and S_2	(1,1)	H_4 and S_4	(1,1)
H_2 and $\overline{S_2}$	(0,0)	H_4 and $\overline{S_4}$	(1,0)

Given the husband's reaction functions and the wife's utility comparisons, the SE can be defined. Table 6 presents the SE for each pair of husband's reaction function and wife's utility comparisons. In Table 6, $\overline{S_j}$ denotes the negation of S_j for $j = 1, 2, 3, 4$. As seen in Table 6, the SE is always unique. For example, for the pair of husband's reaction function and wife's utility comparison (H_1, S_1), the unique SE is (0,1), i.e. the

[15]See Appendix D for the description of SE in Stackelberg-husband leader game.

husband decides not to work and the wife decides to work. The outcome (0,1) is a SE if the pair of the husband's reaction functions and wife's utility comparisons is (H_1, S_1) or (H_3, S_3). Once again, the probability of each observed outcome can be written in terms of the probabilities of that each pair of the reaction function of the husband with the utility comparison of the wife, and hence in terms of model parameters.[16]

2.3 Nash/Pareto Optimality

It is well known that game theoretical models may yield outcomes that are not Pareto optimal. Bargaining models and collective models are based on the hypothesis that household decisions are Pareto optimal. Considering this possibility, we employ the approach suggested by Kooreman (1994) that imposes Pareto optimality on the observed outcomes of the game played between two players.

For the model described in Equation 1, there is a large number of cases with multiple solutions. For model predictability, Kooreman (1994) suggests using the Nash principle to reduce the large number of cases with multiple solutions. In this approach, the husband and the wife are assumed to play a Nash game. If the game has a unique NE and it is Pareto optimal, then it is assumed to be the outcome of the game. If the unique NE is not Pareto optimal, players are assumed to choose the Pareto efficient outcome. If the game has two Nash equilibria in pure strategies and if only one of the Nash equilibria is Pareto optimal, it is assumed to be the outcome of the game. If both NE of the Nash equilibria are Pareto optimal, the players are assumed to choose one of the them with equal probabilities. If the game does not have a NE in pure strategies, then players are assumed to choose one of the Pareto optimal allocations with equal probabilities. [17]

To determine observed outcomes based on the Nash/Pareto optimality model, utility rankings of husband and wife are required. Since there are four possible outcomes, the number of possible utility rankings for a couple is $(4!)^2$. In order to reduce the number of possible cases, it is necessary to impose restrictions on the model parameters. In the family labor supply model the restrictions on parameters, $\alpha_h^1 > 0$, $\alpha_h^0 > 0$, $\alpha_w^1 > 0$ and $\alpha_w^0 > 0$ imply that spouse's employment has a positive effect on individual's utility, so in our analysis we impose that α_h^1, α_h^0, α_w^1 and α_w must be positive.

Once again, using the model parametrization in Equation 1, the utility rankings of the

[16]See Appendix C for details.

[17]Kooreman (1994) shows the existence of the Pareto optimal allocation in each of these cases.

husband and the wife can be written in terms of conditions for the random components ε_h and ε_w. This allows us to write the expressions for each possible outcome of the joint family labor supply, in terms of model parameters.[18]

3 Identification and Estimation

We estimate the game theoretical models described in the previous section using a maximum likelihood estimation strategy assuming that $(\varepsilon_h, \varepsilon_w)$ follow a bivariate normal distribution with zero means, unit variances and correlation ρ. The log-likelihood function for each game theoretical model is as follows:

$$\begin{aligned} L &= \sum_c \log \Pr_c(y_h, y_w) \\ &= \sum_c [y_h y_w \log \Pr_c(1,1) + y_h(1-y_w) \log \Pr_c(1,0) \\ &+ (1-y_h)y_w \log \Pr_c(0,1) + (1-y_h)(1-y_w) \log \Pr_c(0,0)], \end{aligned} \tag{4}$$

where c is the index for each observation, i.e. a couple. To estimate a particular model, expressions for the four outcome probabilities, given in terms of model parameters, are substituted in.[19]

In addition to the game theoretical models, we also consider a model without interactions between spouses' decisions. In particular, we estimate the simultaneous probit model described in Equation 3 by imposing the coherency condition on model parameters. In particular we impose the condition that spouses' decisions do not affect each other's decision, i.e. $\alpha_h = \alpha_w = 0$ and estimate a bivariate probit model.[20]

Because the expressions for probability of observing a given outcome is different in each game theoretical model, all the parameters are not identified in all the models. The identifiable parameters in each model are summarized in Table 7. β_h and β_w are identified in all the models,but β_h^1, β_h^0, β_w^1 and β_w^0 cannot be identified separately. Furthermore, the impact of the wife's employment decision on the husband's utility of not working, α_h^1 and on husband's utility of working, α_h^0 are separately identified only

[18]See Appendix E for details.

[19]See Appendices B, C, D and E for the expressions for each possible outcome probability in Nash model, Stackelberg-wife leader model, Stackelberg-husband leader model and Nash/Pareto optimality, respectively.

[20]This approach is similar to the one suggested by Del Boca (1997) where she models the labor supply decisions of the husband and the wife using a bivariate probit model.

Table 7: Identified parameters in models

Model	**Identified Parameters**
Bivariate probit	α_h and $\alpha_w = 0$, β_h, β_w
Nash	α_h, α_w, β_h, β_w
Stackelberg-husband leader	α_h^1 and α_h^0, α_w, β_h, β_w
Stackelberg-wife leader	α_h, α_w^1 and α_w^0, β_h, β_w
Nash/Pareto optimality	α_h^1 and α_h^0, α_w^1 and α_w^0, β_h, β_w

in the Stackelberg-husband leader model and the Nash model when Pareto optimality is imposed. In the remaining models, only $\alpha_h = \alpha_h^1 - \alpha_h^0$ is identified. On the other hand, the impact of the husband's employment decision on the wife's market and reservation wages (α_w^1 and α_w^0) are separately identified only in the Stackelberg-wife leader model and the Nash model when Pareto optimality is imposed. In the other game theoretical models, only the impact of husband's employment decision on the wife's utility difference between working and not working, $\alpha_w = \alpha_w^1 - \alpha_w^0$ is identified. By construction, in the bivariate probit model, the impact of the spouse's employment decision on an individual's utility is zero, i.e. $\alpha_h = 0$ and $\alpha_w = 0$.

In our analysis, we allow for the behavioral parameters of the models to differ among four types of couples (homogamy-low, heterogamy-husband high, heterogamy-wife high and homogamy-high). Therefore, for each type, we estimate the bivariate probit model and the game theoretical models separately. Then, given the observed employment decision of couples, we determine the way that couples decide their labor supply. In particular, for each couple in the sample, we calculate the predicted probabilities of four possible outcomes — both work, only husband works, only wife works or both do not work — from each model. Next, we determine the model that gives the highest probability for the observed joint employment decision of the couple and assign to the couple this particular model. As a result, for each type (homogamy-low, heterogamy-husband high, heterogamy-wife high and homogamy-high), we compute the fraction of households whose observed decisions are most consistent with a particular model.

Once we assign a particular decision-making process for each household, we predict the marginal probabilities of working for the husband and for the wife from the assigned model. This allows us to calculate labor supply elasticities. In order to do so we increment either the wage of the individual, or the spouse's wage or non-labor family income by one percent. Then using the model parameters, we recalculate the marginal probabilities of working for the husband and for the wife after the increase. Comparing the marginal probability of working for each individual before and after the increments gives us a participation elasticity for the husband and the wife in each couple. Finally, using the labor supply elasticities of each couple, we calculate the average labor supply elasticity of married men and women.

4 Data and Empirical Specification

We use the 2000 Census data for the U.S. obtained from IPUMS-USA. The sample is restricted to married individuals aged 25-54 with a 25- to 54-year-old spouse present, not living in group quarters, not in school and not self-employed. We also exclude from the sample individuals with allocated annual weeks worked or allocated hours worked per year.[21] Since the proportion of nonparticipating males is very small, we focus on working husbands and model the choice between working full-time and working part-time.[22] Therefore, in our analysis of the observed outcomes, y_h and y_w are defined as

$$y_h = \begin{cases} 1 \text{ if husband works at least 35 hrs/wk} \\ 0 \text{ if husband works less than 35 hrs/wk} \end{cases} \text{ and } \; y_w = \begin{cases} 1 \text{ if wife works} \\ 0 \text{ if wife does not work.} \end{cases}$$

One of the key variables in our analysis is educational attainment of husbands and wives. We consider the education level as high if the individual has at least a college degree and as low otherwise. Couples with similar education level (low-low or high-high) are considered to be homogamous, while couples with different education levels (high-low or low-high) are considered to be heterogamous.

In the next step, we specify the set of explanatory variables for the market and reservation wage equations for husbands and wives. The market wage equations of husbands and wives are

$$\begin{aligned} U_h(1, y_w) &= x_h^{'}\beta_h^1 + \alpha_h^1 y_w + \eta_h^1 \\ U_w(y_h, 1) &= x_w^{'}\beta_w^1 + \alpha_w^1 y_h + \eta_w^1, \end{aligned} \tag{5}$$

[21]IPUMS determines the missing, illegible and inconsistent observations and allocates values to these observations using different procedures. IPUMS provides Data Quality Flag variables for these variables to determine allocated observations. See https://usa.ipums.org/usa/flags.shtml for details.

[22]Although in the Fair Labor Standards Act (FLSA), for the U.S. there is no definition of full-time or part-time employment, the 35 hours cut-off point is motivated by the fact that the Bureau of Labor Statistics (BLS) defines those who work for less than 35 hours per week as part-time workers.

where x_h and x_w consist of age, years of education, race dummies, and geographic variables including a regional dummy and a dummy for residence being in a metropolitan statistical area (hereafter MSA), and a constant term. The reservation wage equations for husbands and wives are specified as

$$\begin{aligned} U_h(0, y_w) &= z_h^{'}\beta_h^0 + \alpha_h^0 y_w + \eta_h^0 \\ U_w(y_h, 0) &= z_w^{'}\beta_w^0 + \alpha_w^0 y_h + \eta_w^0. \end{aligned} \tag{6}$$

The set of explanatory variables for the reservation wage equation for husbands, z_h, includes a constant term, non labor family income (defined as the sum of interest, dividends and rent income), his log hourly wage and his wife's log hourly wage. For wives, z_w includes a constant term, non-labor family income, her log hourly wage, her husband's log hourly wage, number of children and a dummy for the presence of 0- to 6-year-old children.

Since our main interest is to calculate the labor supply elasticities, including own wage and spouse's wage in the reservation wage equations is crucial for our analysis. We do not observe wages for non-workers, however, so we use the following procedure to impute wages. First, we define hourly wages as annual earnings divided by annual hours worked for wage and salary workers. Second, we consider hourly wages as invalid if they are allocated or if they are less than \$2 or greater than \$250 per hour in 1999 dollars. Third, we run a separate selectivity bias corrected wage regression for each type of couple (homogamy-low, heterogamy-husband high, heterogamy-wife high and homogamy-high) and for each spouse (husbands and wives) using the Heckman two-step method (Heckman, 1979). In particular, at the first stage, a pair of reduced form probit regressions are run separately for the husband and for the wife for each type of couple of the form:

$$y_h^* = \widetilde{z}_h^{'}\gamma_h + \xi_h,$$

and

$$y_w^* = \widetilde{z}_w^{'}\gamma_w + \xi_w,$$

where

$$y_i \quad = \quad \begin{cases} 1 \; if \; y_i^* > 0 \\ 0 \; otherwise \end{cases} \quad for \; i = h, w, \tag{7}$$

where $\widetilde{z}_h$ and $\widetilde{z}_w$ include the variables that affect the participation decisions of the husbands and wives. We include in $\widetilde{z}_h$ a constant, cubic terms in age and years of education, a race dummy, non-labor family income and geographic variables including regional dummies and a dummy for the size of the MSA of residence. In addition, $\widetilde{z}_h$ and $\widetilde{z}_w$ include the number of children and the presence of children younger than six. At the second stage, we run selection corrected wage regressions for each gender and for each type of couple of the form

$$\ln W_h = \widetilde{x}_h^{'}\delta_h + \omega_h,$$

and

$$\ln W_w = \widetilde{x}_w^{'}\delta_w + \omega_w, \tag{8}$$

where $\widetilde{x}_h$ and $\widetilde{x}_w$ include the inverse Mills ratios calculated from the first stage, a constant term, cubic terms in age and years of education, race and geographic variables including regional dummies and a dummy for the size of the MSA of residence. The exclusion of non-labor income and child variables for wives and non-labor income for husbands at the first stage ensures identification of the inverse Mills ratio term in the second stage. The predicted values for wages obtained from the selection corrected wage equations specified in Equation 7 are imputed for all women and men to minimize the effect of measurement error in wages.[23]

Sample statistics by type of couple are provided in Table 8. Of the 848,835 remaining couples after selection, 79% of them are homogamy type (57.64% low type and 21.31% high type), whereas only 11.90% of them are heterogamy-husband high and 9.14% of them are heterogamy-wife high types. As seen in Table 8, men are more likely to be full-time employed independently of whom they are married to. On the other hand, the employment rate of married women in our sample is around 82% for those with high education and only 75% for those with low education. Hence, a well-known fact is also present in our sample, that women with high education are more likely to be employed than women with low education. What is less known is that, highly educated women are less likely to be employed if they are married to highly educated men. In our sample, among highly educated women, employment rate is lower for women married to men with high education compared to women married to men with low education.

Not surprisingly, wages increase by education level. However, the average hourly wage differs within the same education group depending on the educational similarity between spouses. Among individuals with the same level of education (low or high), the hourly wage is higher for those married to someone with high education than those

[23]The identification of wage coefficients in Equation 5 comes form the exclusion of higher order terms in age and education in z_h and z_w.

Table 8: Summary statistics by type of couples

	Homogamy low	**Heterogamy husband-high**	**Heterogamy wife-high**	**Homogamy high**
Wife				
Employed (%)	0.75	0.70	0.89	0.79
Log hourly wage	2.37	2.48	2.89	2.93
	(0.19)	(0.14)	(0.15)	(0.15)
Age	38.67	40.45	38.32	38.85
	(7.53)	(7.40)	(7.38)	(7.61)
Years of education	11.84	12.76	16.46	16.70
	(2.07)	(1.09)	(0.84)	(0.95)
Race (% white)	0.79	0.86	0.84	0.85
Husband				
Employed full-time (%)	0.97	0.98	0.97	0.98
Log hourly wage	2.73	3.24	2.81	3.26
	(0.22)	(0.16)	(0.18)	(0.18)
Age	40.48	42.54	39.91	40.46
	(7.58)	(7.33)	(7.56)	(7.71)
Years of education	11.81	16.53	12.68	16.86
	(2.09)	(0.88)	(1.12)	(0.99)
Race (% white)	0.79	0.86	0.84	0.86
Family non-labor income	901	3,076	2,053	5,344
(in thousands of dollars per year)	(7,298)	(14,790)	(12,332)	(20,726)
Number of children	1.64	1.53	1.35	1.39
	(1.25)	(1.20)	(1.11)	(1.13)
% with 0–6 years old children	0.25	0.25	0.31	0.33
MSA (%)	0.78	0.88	0.84	0.91
Number of obs.	505,091	96,616	77,043	170,085

Data source: 5% sample of the 2000 Census IPUMS. *Note:* Sample includes married individuals ages 25-54 with a 25-54 year old spouse present, not living in group quarters, not in school, not self-employed and do not have allocated weeks or hours. For husbands, the fraction of employed full time is over the employed husbands. Non-labor family income consists of interest, dividends and rent. Standard deviations in parenthesis.

married to someone with low education. The average non-labor family income also increases by the level of educational attainment. Highly educated couples have the highest non-labor family income. Among heterogamous couples, non-labor family income is higher when the wife is the spouse with low education one and the husband is the highly educated one.

By construction, years of education differ among different types of households. However, within the same level of educational attainment, average years of schooling is higher for individuals that are married to someone with high education. Furthermore, the wives are relatively younger than the husbands. Husbands and wives of heterogamous couples where the wife is the spouse with low education, are slightly older than other types of husbands and wives. More than 82% of the couples in the sample consist of whites, with non-whites being more likely to be of the homogamy-low type. The average number of children is similar among couples. Homogamy-low and heterogamy-husband high type couples have slightly more kids compared to other couples. On the other hand, homogamy-high and heterogamy-wife high type couples are slightly more likely to have children aged 0 to 6 years.

5 Estimation Results

In this section, we present our estimation results. We first provide the key parameter estimates of the bivariate probit model and of the game theoretical models for homogamy-low, heterogamy-husband high, heterogamy-wife high and homogamy-high type couples. Then, using the parameter estimates of each model, we determine the way that couples decide their labor supply. In particular, we assign to each couple the model that gives the highest probability of the observed joint employment decisions of the husband and the wife. This, in turn, allows us to compute the fraction of couples that follow a particular decision-making process. In what follows, we first look at how well the estimated model fits the observed employment rates of husbands and wives. Given that the model provides a satisfactory fit to the data, we then calculate the labor supply elasticities of married women.

5.1 Key Parameter Estimates

Tables 9.a, 9.b, 9.c and 9.d provide the key parameter estimates for homogamy-low, heterogamy-husband high, heterogamy-wife high and homogamy-high type couples, respectively.[24] In all tables, each column represents the key parameter estimates (${\alpha_h}^1$, ${\alpha_h}^0$ α_w^1 and α_w^0), the coefficient estimates of own log wage, spouse's log wage and non-labor income for husbands and wives (β_h and β_w) from a particular model.

We start with the estimates of β_h and β_w. As is evident from Tables 9.a to 9.d, coefficient estimates for own-wage, spouse's wage and non-labor income are similar across models. This implies that, for each type of couple, the impact of own-wage, or spouse's wage, or non-labor income on the individual's reservation wage is independent of the way that household members make their labor supply decisions. For all couples in all models, the labor supply of married women is positively and significantly related to their own wage (i.e. $\beta_w > 0$), and it is negatively and significantly related to the

[24]The full set of estimates are available upon request.

husband's wage and the non-labor family income (i.e. $\beta_w < 0$). On the other hand, there are significant differences across different types of couples. By comparing the first row of Tables 9.a, 9.b, 9.c and 9.d, we conclude that the coefficient estimate for own-wage is highest for wives with low education married to men with low education and smallest for wives with high education married to men with low education (Tables 9.a and 9.c). Coefficient estimates for own-wage for women with low education married to highly educated men and for women with high education married to highly educated men are similar and fall between these two extremes (Tables 9.b and 9.d). Moreover, comparing the second row of Tables 9.a, 9.b, 9.c and 9.d shows that coefficient estimates for the husband's wage are relatively small if women are married to men with low education (Tables 9.a and 9.c) and they are large if women are married to men with high education (Tables 9.b and 9.d). For all women, for each model, the coefficient estimate for the non-labor family income is significant, but it is small compared to coefficient estimates of the own-wage and the spouse's wage (third row of Tables 9.a, 9.b, 9.c and 9.d).

For husbands, on the other hand, coefficient estimates, β_h, indicate that full-time employment of married men is positively and significantly related to their own-wage, and negatively and significantly related to non-labor family income for all types of couples. However, for a particular model, the coefficient estimate for the wife's wage is different between different types of couples. For homogamy-low and heterogamy-husband high types, the full-time employment of the husband is positively and significantly related to the wife's wage. On the contrary, for heterogamy-wife high types, the full-time employment of the husband is negatively and significantly related to the wife's wage. Finally, for homogamy-high types there is no significant relation between the husband's full-time employment and the wife's wage.[25]

Now we turn our attention to estimates of cross-effects. Recall that, for $i = h, w$, α_i^1 and α_i^0 denote the effect of the spouse's employment on the individual's market wage and the reservation wage, respectively. A priori, the spouse's employment is expected to increase the reservation wage of the individual ($\alpha_h^0 > 0$ and $\alpha_w^0 > 0$) and no cross effects are expected on spouses' market wages ($\alpha_h^1 = 0$ and $\alpha_w^1 = 0$). This implies negative estimates of parameters $\alpha_h = \alpha_h^1 - \alpha_h^0$ and $\alpha_w = \alpha_w^1 - \alpha_w^0$. As Tables 9.a to 9.d present, significant estimates of α_h (estimated and implied by the estimates of α_h^1 and α_h^0) are negative for all types.[26] In other words, the employment of the wife

[25]The only exception is the bivariate probit model which predicts a significant negative relation between the husband's full-time employment and the wife's wage.

[26]Only exceptions are Stackelberg-wife leader model for homogamy-low types and the Nash/Pareto

makes her husband less likely to work full-time for all types of couples. However, for wives, significant estimates of α_w (estimated or implied by estimates for α_w^1 and α_w^0) are positive for all types. This implies that the full-time employment of the husband makes his wife more likely to work.

Next, we compare the estimates of the correlation parameter ρ. It is important to note that ρ is not simply the correlation between omitted variables in the husband's and wife's equations. Instead, as is implied by Assumption A.2, the correlation ρ arises from a more complicated relationship between $\varepsilon_h = \eta_h(1, y_w) - \eta_h(0, y_w)$ and $\varepsilon_w = \eta_w(y_h, 1) - \eta_w(y_h, 0)$. Recall that ε_h and ε_w denote the difference between the random utility that the individual derives from working and not working for any given employment decision of the spouse. In families where the division of housework is unbalanced, these terms might be negatively correlated. For instance, consider a couple in which the husband always chooses to work full-time given any decision of the wife. In this case, the wife may take the housework responsibilities, and unless she receives a high-wage offer, she may prefer not to work since her reservation wage increases. In this case, ρ will be negative. On the other hand, consider a couple that both spouses are career-oriented, and enjoy working more than staying at home. In this case, ρ will be positive. Consistent with this explanation, the significant estimates of ρ from game theoretical models is negative for homogamy-low type couples and heterogamous couples (Tables 9.a to 9.c), whereas it is positive for homogamy-high type couples (Table 9.d).

Note that the significant estimates of the parameter ρ from the bivariate probit model and game theoretical models have opposite signs (Tables 9.a and 9.d). In the bivariate probit model, the cross-effects may be picked up by the correlation parameter ρ. In fact, for the homogamy-low type (Table 9.a), the significant estimates of α_h and α_w are positive. Then, for these couples, the estimate of the correlation parameter ρ from the bivariate probit model turns to be positive. However, for the homogamy-high type (Table 9.d) the sign of the correlation parameter estimate ρ is negative in the bivariate probit model, whereas it is positive in game theoretical models. Once again, for homogamy-high types, negative cross effects may be picked up by the correlation parameter ρ in the bivariate probit model.

optimality for heterogamy-wife high types.

Table 9.a: Key parameter estimates, Homogamy-low

Homogamy low		**Bivariate Probit**	**Nash**	**Stackelberg Husband leader**	**Stackelberg Wife leader**	**Nash/ Pareto optimality**
β_w						
	log(wage)	1.920***	1.919***	1.919***	2.006***	1.918***
		(0.027)	(0.027)	(0.027)	(0.032)	(0.027)
	log(husband's wage)	-0.055***	-0.066***	-0.065***	0.028	-0.067***
		(0.015)	(0.016)	(0.016)	(0.019)	(0.016)
	non-labor income	-0.003***	-0.003***	-0.004***	-0.004***	-0.003***
	(in 000 dollars)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_h						
	log(wage)	0.710***	0.717***	0.718***	0.612***	0.721***
		(0.059)	(0.059)	(0.059)	(0.057)	(0.060)
	log(wife's wage)	0.148***	0.207***	0.195***	0.157***	0.197***
		(0.028)	(0.042)	(0.041)	(0.027)	(0.042)
	non-labor income	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(in 000 dollars)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	α_0^w				5.914	-0.290
α^w			0.288**	0.243	(26.512)	(0.179)
	α_1^w		(0.140)	(0.124)	6.112	0.035
					(26.511)	(0.095)
	α_0^h			-0.027		-0.408
α^h			-0.101	(0.132)	0.816***	(0.843)
	α_1^h		(0.053)	-0.119	(0.038)	-0.507
				(0.133)		(0.836)
ρ		0.025***	-0.039	-0.043	-0.106**	-0.068
		(0.005)	(0.051)	(0.055)	(0.045)	(0.062)
Log-likelihood		-324200.69	-324197.93	-324198.05	-324197.55	-324113.56
df		35	37	38	38	39
Number of obs.		505091	505091	505091	505091	505091

Data Source: 5% sample of the 2000 Census IPUMS.

Note: (i) *, ** and *** significant at 1, 5 and 10 % significance level respectively. (ii) See text for the description of the model parameters.

Table 9.b: Key parameter estimates, Heterogamy-husband high

Heterogamy husband high		**Bivariate Probit**	**Nash**	**Stackelberg Husband leader**	**Stackelberg Wife leader**	**Nash/ Pareto optimality**
β_w						
	log(wage)	0.607***	0.583***	0.590***	0.572***	0.611***
		(0.097)	(0.097)	(0.097)	(0.118)	(0.103)
	log(husband's wage)	-0.833***	-0.820***	-0.824***	-0.842***	-0.852***
		(0.042)	(0.043)	(0.042)	(0.058)	(0.044)
	non-labor income	-0.006***	-0.005***	-0.006***	-0.005***	-0.006***
	(in 000 dollars)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_h						
	log(wage)	0.984***	0.702***	0.777***	0.068	0.741**
		(0.180)	(0.205)	(0.192)	(0.180)	(0.236)
	log(wife's wage)	0.239**	0.343**	0.348***	0.448***	0.473***
		(0.087)	(0.120)	(0.096)	(0.090)	(0.114)
	non-labor income	-0.003***	-0.003***	-0.003***	-0.003***	-0.004***
	(in 000 dollars)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	α_0^w				2.108***	1.018***
α^w			1.258	0.761**	(0.179)	(0.298)
	α_1^w		(0.795)	(0.237)	2.990***	3.687***
					(0.160)	(0.415)
	α_0^h			0.275*		1.179***
α^h			-0.371	(0.131)	-0.781***	(0.124)
	α_1^h		(0.340)	0.010	(0.049)	0.908***
				(0.164)		(0.146)
ρ		-0.013	-0.330	-0.161	-0.226**	-0.202
		(0.012)	(0.189)	(0.101)	(0.075)	(0.114)
Log-likelihood		-65068.33	-65058.11	-65060.60	-65016.05	-65049.35
df		35	37	38	38	39
Number of obs.		96616	96616	96616	96616	96616

Data Source: 5% sample of the 2000 Census IPUMS.

Note: (i) *, ** and *** significant at 1, 5 and 10 % significance level respectively. (ii) See text for the description of the model parameters.

Table 9.c: Key parameter estimates, Heterogamy-wife high

Heterogamy wife high		**Bivariate Probit**	**Nash**	**Stackelberg Husband leader**	**Stackelberg Wife leader**	**Nash/ Pareto optimality**
β_w						
	log(wage)	0.077	0.060	0.062	0.355	0.036
		(0.159)	(0.158)	(0.158)	(0.225)	(0.177)
	log(husband's wage)	-0.173**	-0.227***	-0.186**	-0.672***	-0.070
		(0.063)	(0.064)	(0.063)	(0.112)	(0.074)
	non-labor income	-0.005***	-0.005***	-0.005***	-0.006***	-0.010***
	(in 000 dollars)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
β_h						
	log(wage)	1.134***	0.991***	0.952***	0.826***	1.005***
		(0.213)	(0.227)	(0.222)	(0.192)	(0.207)
	log(wife's wage)	-0.277**	-0.233*	-0.230*	-0.254**	-0.333***
		(0.097)	(0.103)	(0.100)	(0.093)	(0.098)
	non-labor income	-0.003***	-0.004***	-0.003***	-0.003***	-0.005***
	(in thousand dollars)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	α_0^w				2.801***	7.259
α^w			2.101***	1.060**	(0.262)	(94.967)
	α_1^w		(0.336)	(0.365)	3.753***	7.219
					(0.228)	(94.976)
	α_0^h			0.518**		0.462***
α^h			-0.957**	(0.180)	-0.397***	(0.092)
	α_1^h		(0.360)	0.305	(0.029)	1.624***
				(0.272)		(0.132)
ρ		-0.005	-0.555***	-0.192	-0.266**	0.153
		(0.016)	(0.114)	(0.160)	(0.102)	(0.122)
Log-likelihood		-34748.79	-34741.43	-34741.21	-34704.29	-34726.17
df		35	37	38	38	39
Number of obs.		77043	77043	77043	77043	77043

Data Source: 5% sample of the 2000 Census IPUMS.

Note: (i) *, ** and *** significant at 1, 5 and 10 % significance level respectively. (ii) See text for the description of the model parameters.

Table 9.d: Key parameter estimates, Homogamy-high

Homogamy high		**Bivariate Probit**	**Nash**	**Stackelberg Husband leader**	**Stackelberg Wife leader**	**Nash/ Pareto optimality**
β_w						
	log(wage)	0.872***	0.851***	0.865***	0.862***	0.861***
		(0.081)	(0.081)	(0.081)	(0.082)	(0.081)
	log(husband's wage)	-1.057***	-1.054***	-1.053***	-1.055***	-1.056***
		(0.035)	(0.035)	(0.035)	(0.036)	(0.035)
	non-labor income (in 000 dollars)	-0.005***	-0.005***	-0.005***	-0.005***	-0.005***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_h						
	log(wage)	0.942***	0.677***	0.742***	0.731***	0.715***
		(0.089)	(0.103)	(0.111)	(0.112)	(0.108)
	log(wife's wage)	-0.172**	-0.035	-0.059	-0.066	-0.059
		(0.057)	(0.063)	(0.065)	(0.067)	(0.066)
	non-labor income (in 000 dollars)	-0.001***	-0.002***	-0.002***	-0.002***	-0.002***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	α_0^w				-0.587*	-2.089
α^w			0.456	-0.007*	(0.253)	(1.977)
	α_1^w		(0.307)	(0.003)	-0.196	-1.880
					(0.388)	(1.970)
	α_0^h			4.792		0.330***
α^h			-0.380***	(10.009)	-0.360***	(0.099)
	α_1^h		(0.088)	4.416	(0.063)	0.025
				(10.008)		(0.036)
ρ		-0.059***	-0.048	0.190***	0.037	0.003
		(0.010)	(0.108)	(0.051)	(0.114)	(0.148)
Log-likelihood		-96931.92	-96918.14	-96917.21	-96917.04	-96916.89
df		35	37	38	38	39
Number of obs.		170085	170085	170085	170085	170085

Data Source: 5% sample of the 2000 Census IPUMS.

Note: (i) *, ** and *** significant at 1, 5 and 10 % significance level respectively. (ii) See text for the description of the model parameters.

5.2 Distribution of Couples

Given the parameter estimates, we select the model that best predicts the observed joint labor supply behavior of each couple in the sample. To assess the model fit in terms of the employment rate of wives and full-time employment rate of husbands, Table 10 presents the actual and the predicted values for different types. As shown in Table 10, the model performs well at predicting the employment rates of wives and husbands for different types of couples.

Table 10: Actual and predicted employment rates

	Employment rate of wives		**Full-time employment rate of husbands**	
	Actual	**Predicted**	**Actual**	**Predicted**
Homogamy-low	0.75	0.76	0.89	0.90
Heterogamy-husband high	0.70	0.71	0.79	0.79
Heterogamy-wife high	0.89	0.90	0.97	0.97
Homogamy-high	0.79	0.79	0.98	0.98

Because we assign each couple in the sample the model that best predicts the observed joint labor supply behavior, we know the fraction of couples that follow a particular decision-making process. The resulting distribution of couples is presented in Table 11. As Table 11 shows, for most of the homogamy high couples, the observed labor supply decisions of couples is best predicted by the bivariate probit model. Recall that in the bivariate probit model, the cross effects of employment decisions are assumed to be zero. This implies that most of the highly educated spouses (about 46%) make their labor supply decisions independent of each other. For these couples around 27% of household decisions can be justified as coming from a Nash game.

On the other hand, for the majority of homogamy-low and both heterogamy types, the labor supply decisions of spouses exhibit strong interactions. The decisions of a majority of these couples are best predicted by the Stackelberg-wife leader model. Hence, when the wife decides whether to work or not, she knows the action that her husband will take given her choice, and in making her labor supply decision she takes the husband's payoff into account and optimizes accordingly. For around 20% of homogamy-low and 25% of heterogamy couples, the household decisions are best predicted by the Nash/Pareto optimality model.

Table 11: Distribution of couples by type

	Bivariate Probit	Nash	Stackelberg Husband leader	Stackelberg Wife leader	Nash/ Pareto optimality
Homogamy-low	14.3%	14.9%	0.2%	50.7%	19.9%
Heterogamy-husband high	15.9%	4.0%	2.6%	52.5%	24.9%
Heterogamy-wife high	19.2%	3.2%	3.3%	48.3%	26.1%
Homogamy-high	45.5%	26.8%	16.1%	7.5%	4.0%

At first it may be surprising that for most of the homogamy-low and both heterogamy types, the joint labor supply decision is best predicted by Stackelberg-wife leader model. In the empirical literature, there are some examples that model the household decisions as the outcome of a Stackelberg game played between spouses. For instance, Bolin (1997), and Beblo and Robledo (2002) consider Stackelberg (husband leader) game to model intra-family time allocation. They suggest that the spouse with more bargaining power, gets to be the leader in the Stackelberg game. On the other hand, Kooreman (1994) finds that the Stackelberg wife leader model gives the best description of household participation decisions in a sample of Dutch households. Chao (2002) also shows that Stackelberg wife leader model outperforms in predicting contraceptive choice of married couples compared to the consensual approach and of a non-cooperative Nash game.

The literature on gender identity and division of work within a household suggests that traditional gender roles may lead women to lower their labor force participation. For instance, Bertrand, Kamenica and Pan (2013) focus on the behavioral prescription that "*a man should earn more than his wife*" and show that traditional gender roles distort labor market outcomes of women. Their analysis suggest that, since departing from the traditional gender roles increases the likelihood of a divorce, married women sometimes stay out of the labor force in order to avoid a situation where they would become the primary breadwinner. Similarly, Akerlof and Kranton (2000) study the relation between traditional gender roles and economic outcomes. They argue that if deviating from the prescription — "*men work in the labor force and women work in home*" — is costly then women are less likely to participate to the labor force.

These studies suggest that a woman's labor force participation decision might depend on her perception of how her husband will react if she decides to work. Then, taking her husband's reaction into account, the wife will decide how to proceed. Indeed, in our sample, in more than 72% of the couples that are best described by the Stackelberg-wife leader game, the husband works full-time and the wife works as well, i.e. $(y_h, y_w) = (1, 1)$. Following the traditional gender roles, suppose that a husband prefers working full time while his wife stays home to working full time while she works, i.e. $U_h(1,0) > U_h(1,1)$, but prefers working full time while his wife works to working part time while his wife works, i.e. $U_h(1,1) > U_h(0,1)$. Hence from the man's perspective the ideal outcome is him working full-time and his wife not working. Suppose on the other hand that the wife derives a lower utility from not working than working, i.e. $U_w(1,1) > U_w(1,0)$ and $U_w(0,1) > U_w(0,0)$, i.e. she prefers to work. Then it is logical for the wife to decide to work and make it known to her husband. Given his wife's decision, then the husband will end up working full-time. Hence, the outcome will be $(y_h, y_w) = (1, 1)$.

While these particular gender roles might be relevant for all types of couples, it is particularly relevant for the case of highly educated women married to men with low education. In fact, the largest fraction of couples with an observed outcome $(y_h, y_w) = (1, 1)$ that follow a Stackelberg-wife leader game is among heterogamy-wife high types. In particular, about 89% of heterogamy-wife high type couples that follow a Stackelberg-wife leader game has an observed outcome $(y_h, y_w) = (1, 1)$. For heterogamy-wife high types, it is logical to think that the highly educated wife would be more attached to the market than her husband who has low education.

5.3 Labor Supply Elasticities of Married Women

We now turn our attention to the labor supply estimates of married women. Table 12 presents the average own-wage, cross-wage and income elasticities of participation for married women by type. The average labor supply elasticities of married women varies to a great extent for different types.[27] The average participation own-wage elasticity is largest (0.77) for women with low education married to men with low education, and smallest (0.03) for women with high education married to men with low education. The own-wage elasticities for women with low education married to men with high education and for women with high education married to men with high education are similar and fall between these two extremes (0.30 and 0.31 respectively). Furthermore, cross-wage elasticities for married women are relatively small (less than -0.05) if they

[27] For all types of couples, labor supply elasticities of married men are small and the differences between the labor supply elasticities of different types are negligible. See Table F.1 of Appendix F for labor supply elasticities of married men.

are married to men with low education and larger (about -0.37) if they are married to men with high education. For all types of couples, participation elasticity of non-labor family income for married women is small.

Table 12: Labor supply elasticities of married women by type of couples

	Own wage	**Husband's wage**	**Non-labor income**
Homogamy-low	0.77	-0.02	-0.001
	(0.000)	(0.000)	(0.000)
Heterogamy-husband high	0.30	-0.37	-0.012
	(0.000)	(0.001)	(0.000)
Heterogamy-wife high	0.03	-0.05	-0.004
	(0.000)	(0.000)	(0.000)
Homogamy-high	0.31	-0.38	-0.016
	(0.000)	(0.001)	(0.000)

Note: Standard errors in parenthesis.

What about the distribution of labor supply elasticities? Since our labor supply elasticity calculations are based on the predictions of marginal probability of working for each woman before and after an increment of her own wage, or her husband's wage, or non-labor family income, we know the distributions of labor supply elasticities. Since for all types of couples the participation non-labor family income elasticity of married women is small, we focus on the distributions of own-wage elasticities and cross-wage elasticities.

The distribution of own-wage elasticities of married women is presented in Figure 1. First, for all types of couples, the distribution of labor supply own-wage elasticity of married women is right-skewed with no women having a negative elasticity. However, for all types, there exist women with labor supply own-wage elasticity that is close to zero, implying that for these women, own-wage increases have relatively small effects on their labor supply. Second, the dispersion of labor supply own-wage elasticity distribution differs considerably across different types. In particular, the distribution is more dispersed for homogamy-low types. The long upper tail of the elasticity distribution for homogamy-low type couples implies that among these families there are women with large labor supply own-wage elasticity (with a maximum of 3.36). On the other hand, the dispersion is smallest for heterogamy-wife high types. In other words, for these types, the labor supply own-wage elasticities of married women are concentrated around the mean which is close to zero (about 0.03). Hence, for heterogamy-wife high types, the labor supply of all women show little responsiveness to the changes in their own-wages. The dispersions of the labor supply own-wage elasticity distributions for heterogamy-husband high and homogamy-high types lie between these two extremes.

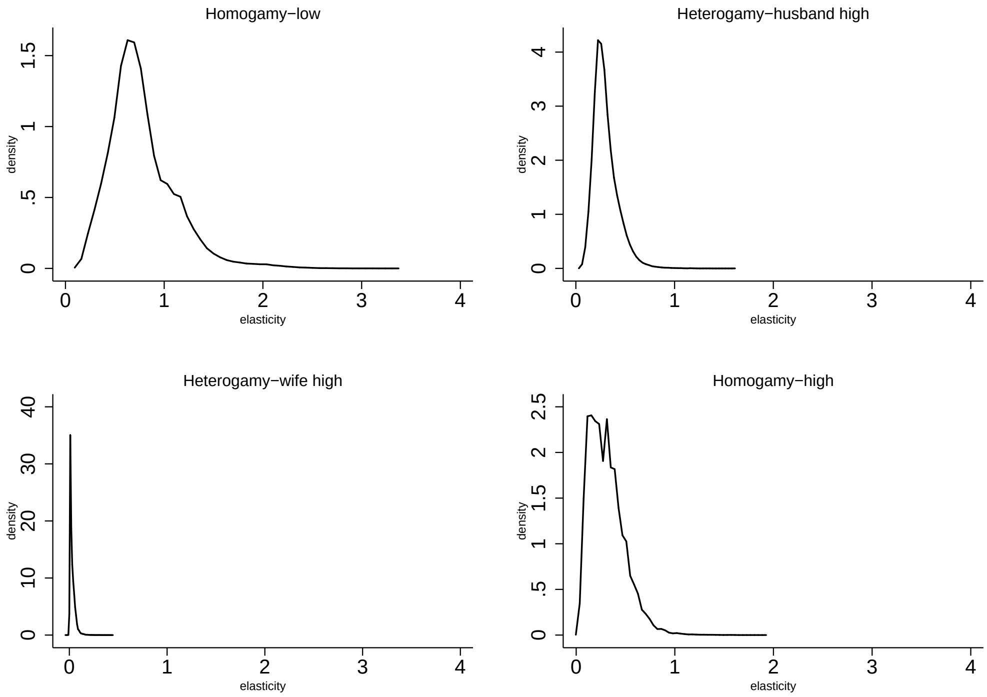

Figure 1: Kernel density of participation own-wage elasticities of married women by type of couples

The distribution of cross-wage elasticities of married women is presented in Figure 2. In this case, since the cross-wage elasticity is negative, the responsiveness of women to changes in their husbands' wages increases as you move to the left of the elasticity distribution. Note that, for all types of couples, the distributions of cross-wage elasticities are left-skewed. For all types, there are some women for which the cross-wage elasticity is close to zero, implying that, for these women, increases in their husbands' wages have relatively small effects on their labor supply. For the majority of women in all types, the cross-wage elasticities are negative. The only exceptions to this general trend can be found in heterogamy-wife high types. Among heterogamy-wife high type couples, there are wives with positive cross-wage labor supply elasticity (with a maximum of 0.19). As seen in Figure 2, the dispersion of labor supply cross-wage elasticity differs between different types. Contrary to the labor supply own-wage elasticity distribution, the labor supply cross-wage elasticity distribution is less dispersed for homogamy-low types. For these couples, the cross-wage elasticities of married women are concentrated around the mean which is close to zero (about -0.02). Similar to the dispersion of the own-wage elasticity distribution, the dispersion of the cross-wage elasticity distribution for heterogamy-wife high types is small. Therefore, for homogamy-low and heterogamy-wife high types, the labor supply of all women shows little responsiveness to changes in their husbands' wages. On the other hand, the dispersions of cross-wage elasticity distributions for heterogamy-husband high and homogamy-high types are similar and larger than those of other types.

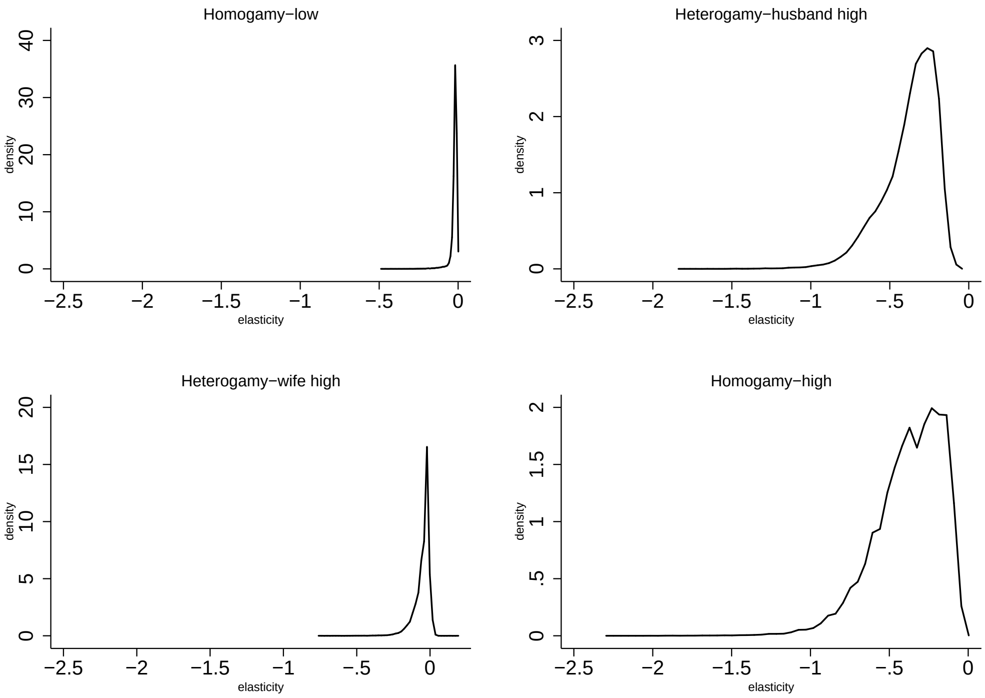

Figure 2: Kernel density of participation cross-wage elasticities of married women by type of couples

As Heim (2007) notes, a high participation elasticity implies that the market wages must be close to the reservation wage. Therefore, a small increase in wages or a decrease in spouse's wage or income will lead women to participate. Particularly, this might be the case for women with low education, since their employment and career opportunities are lower compared to women with high education (Cohen and Bianchi, 1998). On the other hand, if employment and career opportunities vary among women of a particular type, then for this type the distribution of labor supply elasticities of married women will be more dispersed. In fact, for homogamy-low types, the unconditional distribution

Table 13: Characteristics of couples with labor supply own-wage elasticities below and above the average elasticity

	Homogamy low		**Heterogamy husband-high**		**Heterogamy wife-high**		**Homogamy high**	
	Below	Above	Below	Above	Below	Above	Below	Above
Wife								
Employed (%)	0.84	0.64	0.79	0.57	0.91	0.86	0.89	0.67
Log Hourly wage	2.44	2.29	2.58	2.57	2.83	2.83	2.95	2.93
	(0.15)	(0.18)	(0.14)	(0.14)	(0.15)	(0.13)	(0.18)	(0.14)
Age	39.36	37.68	41.89	38.36	38.88	37.37	39.40	38.17
	(7.09)	(8.01)	(7.47)	(6.76)	(7.79)	(6.53)	(8.59)	(6.11)
Years of education	12.59	10.76	12.93	12.51	16.57	16.27	16.96	16.37
	(0.80)	(2.74)	(0.83)	(1.34)	(0.90)	(0.69)	(1.00)	(0.78)
Race (% white)	0.83	0.74	0.88	0.82	0.84	0.84	0.87	0.81
Husband								
Employed full-time (%)	0.97	0.97	0.98	0.98	0.96	0.99	0.97	0.98
Log Hourly wage	2.76	2.67	3.19	3.21	2.85	2.88	3.25	3.33
	(0.18)	(0.23)	(0.19)	(0.18)	(0.17)	(0.16)	(0.22)	(0.16)
Age	41.17	39.48	43.61	40.99	40.55	38.83	40.75	40.11
	(7.28)	(7.88)	(7.46)	(6.84)	(7.91)	(6.79)	(8.71)	(6.23)
Years of education	12.23	11.20	16.44	16.67	12.62	12.76	16.82	16.91
	(1.32)	(2.74)	(0.83)	(0.94)	(1.14)	(1.03)	(0.98)	(1.00)
Race (% white)	0.83	0.74	0.88	0.85	0.84	0.84	0.87	0.83
Family non-labor income	668	1,237	1,534	5,309	1,466	3,042	2,842	8,426
(in 000 dollars per year)	(4,398)	(10,095)	(4,524)	(22,299)	(8,464)	(16,912)	(8,937)	(29,033)
Number of children	1.22	2.24	0.96	2.36	0.90	2.09	0.73	2.20
	(1.04)	(1.28)	(0.92)	(1.07)	(0.96)	(0.92)	(0.82)	(0.90)
% with 0-6 years old children	0.08	0.49	0.04	0.55	0.12	0.63	0.11	0.60
MSA (%)	0.76	0.82	0.84	0.93	0.81	0.89	0.87	0.96
Number of obs.	300,239	204,852	57,466	39,150	48,712	28,331	94,580	75,505

Data source: 5% sample of the 2000 Census IPUMS. *Note:* Sample includes married individuals ages 25-54 with a 25-54 year old spouse present, not living in group quarters, not in school, not self-employed and do not have allocated weeks or hours. For husbands, the fraction of employed full time is over the employed husbands. Non-labor family income consists of interest, dividends and rent. Standard deviations in parenthesis.

of own-wage for married women exhibits the largest variation, which is consistent with the large dispersion of their labor supply own-wage elasticity distribution (See Table 8).

In Tables 13 and 14, we present the characteristics of different types of couples by the labor supply responsiveness of wives to changes in their own wages and to changes in their husbands' wages, respectively. For each type, the first column (*Below*) shows the characteristics of couples with wives whose labor supply elasticities are below or equal to the average labor supply elasticity. On the other hand, the second column (*Above*) presents the characteristics of families with wives whose labor supply own-wage elasticities are above the average. Note that the own-wage elasticity of married women is positive and the cross-wage elasticity is negative. This implies that in Table

13, the labor supply responsiveness of married women to changes in their own wages is higher if their labor supply elasticities are above average. In Table 14, on the other hand, the labor supply responsiveness of married women to changes in their husbands' wages is higher if their elasticities are below or equal to average. Tables 14 and 15 show that, for all types, married women whose labor supply is more elastic (to their own or their husband's wage) are less likely to be employed, less educated, younger and less likely to be white. Their husbands are also more likely to be young and less likely to be white. For homogamy-low types, if the labor supply of married women is more elastic, their husbands earn on average less and they are less educated. However, for other types of couples, the average hourly log wage of husbands is higher and the husbands are more educated for women whose labor supply is more elastic. For all types, the labor supply of married women is more elastic if they have more children and a pre-school age child.

5.3.1 The role of children

A striking difference between women whose labor supply elasticity is below or equal to the average elasticity and women with labor supply elasticities above the average is the difference in their likelihood of having children. Since the labor supply elasticity of different types varies considerably, one can think of the presence of pre-school age children as the source of heterogeneity among different types of couples. In fact, Del Boca (1997), as well as Lundberg (1988) test alternative theories of family labor supply behavior and find that the presence of young children has a crucial effect on household interactions.

Although we control for the number of children and the presence of pre-school age children in the reservation wage equation of wives, it is possible that household interactions are different for couples with and without pre-school age children. One possibility is that children affect the way a couple makes its labor supply decisions. However, since we allow for each couple to differ in the way they make their labor supply decisions, this should not alter our results. Still, if there are large differences between the labor supply elasticities of couples with and without pre-school age children for some types but not for others, then differential responses of married women based on the spouses' education levels might depend on presence of children in the household. Considering this possibility, we compare the distribution of couples and the labor supply elasticities of married women of different types by the presence of 0–6 years old children. Tables 15 and 16 present these results.

Table 14: Characteristics of couples with labor supply cross-wage elasticities below and above the average elasticity

	Homogamy low		**Heterogamy husband-high**		**Heterogamy wife-high**		**Homogamy high**	
	Below	Above	Below	Above	Below	Above	Below	Above
Wife								
Employed (%)	0.68	0.80	0.55	0.81	0.83	0.93	0.67	0.89
Log Hourly wage	2.29	2.44	2.57	2.58	2.83	2.83	2.93	2.95
	(0.18)	(0.15)	(0.14)	(0.14)	(0.13)	(0.15)	(0.14)	(0.18)
Age	37.58	39.34	38.47	41.81	37.27	38.93	38.16	39.41
	(7.85)	(7.25)	(6.80)	(7.48)	(6.37)	(7.86)	(6.12)	(8.59)
Years of education	10.65	12.56	12.53	12.92	16.24	16.59	16.37	16.96
	(2.82)	(0.82)	(1.35)	(0.84)	(0.65)	(0.91)	(0.78)	(1.00)
Race (% white)	0.73	0.83	0.83	0.87	0.86	0.83	0.81	0.87
Husband								
Employed full-time (%)	0.97	0.97	0.98	0.98	0.97	0.97	0.98	0.97
Log Hourly wage	2.67	2.76	3.22	3.19	2.88	2.85	3.33	3.26
	(0.23)	(0.18)	(0.17)	(0.19)	(0.16)	(0.17)	(0.16)	(0.22)
Age	39.29	41.20	41.06	43.55	39.19	40.33	40.10	40.76
	(7.74)	(7.39)	(6.83)	(7.48)	(6.89)	(7.89)	(6.24)	(8.71)
Years of education	11.10	12.24	16.71	16.41	12.71	12.66	16.91	16.82
	(2.82)	(1.31)	(0.96)	(0.81)	(1.14)	(1.09)	(1.00)	(0.98)
Race (% white)	0.73	0.83	0.86	0.87	0.86	0.82	0.83	0.87
Family non-labor income	1,276	673	5,256	1,579	2,940	1,531	8,395	2,855
(in 000 dollars per year)	(10,368)	(4,484)	(22,177)	(5,065)	(16,610)	(8,858)	(28,980)	(9,005)
Number of children	2.29	1.24	2.34	0.98	2.12	0.89	2.20	0.72
	(1.28)	(1.05)	(1.08)	(0.94)	(0.96)	(0.92)	(0.90)	(0.82)
% with 0-6 years old children	0.49	0.10	0.54	0.04	0.65	0.10	0.60	0.11
MSA (%)	0.82	0.76	0.93	0.84	0.90	0.80	0.96	0.87
Number of obs.	188,959	316,132	38,925	57,691	28,058	48,985	75,687	94,398

Data source: 5% sample of the 2000 Census IPUMS. *Note:* Sample includes married individuals ages 25-54 with a 25-54 year old spouse present, not living in group quarters, not in school, not self-employed and do not have allocated weeks or hours. For husbands, the fraction of employed full time is over the employed husbands. Non-labor family income consists of interest, dividends and rent. Standard deviations in parenthesis.

Not surprisingly, the fraction of couples whose employment decisions follow the bivariate probit model is smaller for the ones with pre-school age children. Thus, consistent with the findings of Lundberg (1988), labor supply decisions of spouses are more likely to be independent of each other if there are no children of pre-school age in the household. The presence of children matters most for homogamy-high couples. While without children, we do not observe any interactions for the majority of households (64%). However, those with children take their employment decisions following a non-cooperative Nash game (51%).

How do these results affect the labor supply elasticities of married women? Table 16 presents the labor supply elasticities of married women of different types by the presence of pre-school age children. As expected, the elasticity estimates are larger for mothers

Table 15: Distribution of couples by presence of 0-6 years old children

	Bivariate Probit	Nash	Stackelberg Husband leader	Stackelberg Wife leader	Nash/ Pareto optimality
With 0–6 years old children					
Homogamy-low	7.0%	35.5%	0.0%	42.6%	14.9%
Heterogamy-husband high	2.2%	9.7%	5.3%	53.7%	29.0%
Heterogamy-wife high	3.4%	3.4%	8.5%	59.2%	25.6%
Homogamy-high	7.7%	51.7%	21.6%	12.2%	6.8%
Without 0–6 years old child					
Homogamy-low	16.6%	8.2%	0.3%	53.5%	21.5%
Heterogamy-husband high	20.4%	2.2%	1.7%	52.1%	23.6%
Heterogamy-wife high	26.1%	3.1%	1.1%	43.5%	26.3%
Homogamy-high	64.0%	14.6%	13.5%	5.3%	2.7%

of young children. This pattern is true for all types of households. The participation wage elasticity is once again highest for women with low education married to men with low education and smallest for women with high education married to men with low education both for mothers of pre-school age children and other women. Their cross-wage and income elasticities suggest little responsiveness of labor supply of those women to changes in the husband's wage or changes in non-labor income. As before, independently of whether or not they have 0- to 6-year-old children, own-wage, cross-wage and income elasticities of women with high education are as large as women with low education if they are married to men with high education. Hence, we conclude that differential responses of married women based on spouses' education levels are present among married women, independent of whether children are present in the household or not.

5.3.2 Aggregate Labor Supply Elasticities of Married Women

Given labor supply elasticities and population shares of different types, we calculate the aggregate participation elasticity of married women. Formally, the aggregate participation elasticity is calculated as

$$\sum_k P_k \epsilon_k = \epsilon \tag{9}$$

Table 16: Labor supply elasticities of married women by the presence of 0-6 years old children

	Own wage	Husband's wage	Non-labor income
With 0-6 years old children			
Homogamy-low	1.07	-0.04	-0.001
	(0.001)	(0.000)	(0.000)
Heterogamy-husband high	0.44	-0.57	-0.013
	(0.001)	(0.001)	(0.001)
Heterogamy-wife high	0.05	-0.10	-0.005
	(0.000)	(0.000)	(0.000)
Homogamy-high	0.45	-0.56	-0.020
	(0.001)	(0.001)	(0.000)
Without 0-6 years old child			
Homogamy-low	0.68	-0.02	-0.001
	(0.000)	(0.000)	(0.000)
Heterogamy-husband high	0.25	-0.31	-0.011
	(0.000)	(0.000)	(0.000)
Heterogamy-wife high	0.02	-0.03	-0.003
	(0.000)	(0.000)	(0.000)
Homogamy-high	0.24	-0.29	-0.015
	(0.000)	(0.000)	(0.000)

Note: Standard errors in parenthesis.

where P_k is the proportion of women that are of the type k and ϵ_k is the estimated (own-wage, or cross-wage, or income) elasticity for married women of the type k. We find that the aggregate wage elasticity is 0.56, the cross-wage elasticity is -0.13, and the non-labor family income elasticity is -0.006 for married women. It is important to note that this formulation of the overall participation elasticity captures the heterogeneity among couples in the way they make their labor supply decisions, and, as a result, differences in their labor supply responsiveness.

How large are these elasticities? Heim (2007) and Blau and Kahn (2007) provide recent estimates of labor supply elasticities for married women in the U.S. Heim (2007) reports a participation own-wage elasticity of 0.03 and a participation income elasticity of -0.05 in 2003. On the other hand, different models estimated by Blau and Kahn (2007) yield participation wage elasticities between 0.27 and 0.30, cross-wage elasticities between -0.13 and -0.10, and income elasticities between -0.002 and -0.004 in 2000.

One of the main differences between our study and these studies is that we allow for household interactions and we let these interactions differ across different types of households. To understand the role of each of these factors, we conduct several exercises.

In one scenario, Scenario I, we ignore differences between couples. Hence we assume that all couples make their labor supply decisions in the same way and there are no differences between types. We re-estimate all models for all couples ignoring types, obtaining one set of behavioral parameter estimates for each model for all couples. Then, we assign to all couples one particular model as their way of decision-making and calculate labor supply elasticities using parameter estimates of this model. As the preferences of husbands and wives are not directly observed, we consider three alternatives for assigning all couples the same decision-making mechanism. The first alternative is assigning couples the model that best predicts the observed outcome of the majority. We find that 43% of the couples' observed decisions are best predicted by Stackelberg-wife leader model. Hence the first possibility we consider is assigning to all couples Stackelberg-wife leader model as the way of their decision-making, and calculating labor supply elasticities using parameter estimates of this model (Scenario I-majority). The second alternative is assigning couples the model that best performs based on the goodness of fit. To compare model performances of all models, we use Akaike and Bayesian information criteria, as well as the Likelihood Dominance Criterion suggested by Pollak and Wales (1991). According to these criteria, Nash/Pareto optimality is the model that performs better compared to other models. Hence we assign couples the Nash/Pareto optimality model as their decision-making mechanism and recalculate labor supply elasticities using parameter estimates of this model (Scenario I-best-fit). Finally, we assume that all couples make their labor supply decisions independently. Hence, we use the simultaneous probit model parameter estimates for all couples to calculate labor supply elasticities (Scenario I-no interaction).

In an alternative scenario, Scenario II, we account for differences between types, but assume that couples of a particular type are the same in the way that they make labor supply decisions. For this purpose, we assign couples of a particular type one decision-making model. Then, using parameter estimates of the model for this type, we calculate labor supply elasticities. Finally, using population shares and elasticity estimates of types, we calculate aggregate labor supply elasticities. As in Scenario I, we consider three alternatives for assigning models to couples. First, we consider assigning couples of each type the model that best predicts the behavior of the majority of this type (Scenario II-majority). For this purpose, we use the information presented in Table 11, and assign homogamy-low and heterogamy types the Stackelberg-wife leader model and homogamy-high types the bivariate probit model. Second, we consider assigning couples of each type, the model that performs better compared to other models based on Akaike and Bayesian information criteria, as well as the Likelihood Dominance Criterion (Scenario II-majority). Comparing the goodness-of-fit in terms of these criteria, we find that the Stackelberg-wife leader model performs better than other models for each type. Therefore, we assign all types the Stackelberg-wife leader model. Finally, we assume that husbands and wives make their labor supply decisions independent from each other and use the simultaneous probit model parameter estimates for each type to calculate labor supply elasticities of different types and calculate the aggregate labor supply elasticity (Scenario II-no interaction).

Table 17: Labor supply elasticities of married women, alternative scenarios

	Own wage	**Husband's wage**	**Non-labor income**
Benchmark	0.56	-0.13	-0.006
Scenario I-Majority	0.29	-0.26	-0.006
Scenario I-Best-fit	0.20	-0.23	-0.007
Scenario I-No interaction	0.27	-0.23	-0.007
Scenario II-Majority	0.46	-0.22	-0.093
Scenario II-Best-fit	0.46	-0.22	-0.094
Scenario II-No interaction	0.48	-0.23	-0.097

The elasticity estimates based on different scenarios are presented in Table 17. For comparison, benchmark elasticities are shown in the first row. In both scenarios, we find that the labor supply own-wage elasticity for married women is smaller than our benchmark estimates. Ignoring the differences between types has a significant effect on labor supply own-wage elasticities. When we ignore the heterogeneity among couples in educational attainments of husbands and wives, we find participation own-wage elasticities between 0.20 and 0.29. Note that the elasticity calculated in Scenario I-no interaction is similar to the elasticity estimates of Blau and Kahn (2007) who without considering the household interactions and heterogeneity among couples find participation wage elasticities between 0.27 and 0.30 in 2000. Furthermore, under Scenario II, we find elasticities between 0.46 and 0.48 which are much higher than elasticities under Scenario I, but smaller than our benchmark estimates. In other words, not taking into account the heterogeneity among couples in the way that they make their labor supply decisions underestimates the labor supply elasticities (0.56 versus 0.48). However, ignoring the differences between different types underestimates the labor supply elasticities even more (0.27 versus 0.56). This suggests the crucial role of considering differences between couples in education levels of spouses for estimating labor supply elasticities of married women.

6 Declining Labor Supply Elasticities

Our results show that labor supply elasticities differ greatly among households. This raises a natural question: What is the impact of compositional changes in the population on women's overall labor supply elasticities? From 1980 to 2000, the population share of couples changed considerably. Both women and men in 2000 were more educated than their counterparts in 1980. Moreover, there had been an increase in the educational resemblance of spouses in the United States (Mare, 1991; Pencavel, 1998; Schwartz and Mare, 2005).

In order to get an idea of the effect of compositional changes on married women's labor supply responsiveness, we carry out the following counterfactual exercise. We calculate what the aggregate labor supply elasticities would be, if married women had the responsiveness of 2000 but the distribution of couples had been that of 1980. For this purpose, we calculate the overall labor supply elasticities of married women from Equation 9, using the elasticity estimates for year 2000 and the population shares of couples in 1980.[28] The population shares of different types of couples in 1980 and in 2000 are presented in the first panel of Table 18. As noted by earlier studies, from 1980 to 2000, there was an increase in the fraction of homogamy-high types. In addition, there was an increase in the share of heterogamy-wife high types reflecting the increase in educational attainment levels of women during the recent decades.

The second panel of Table 18 presents the labor supply elasticities under the counterfactual distribution of couples. For comparison, benchmark elasticities based on the actual shares of couples in 2000 are shown in the last row of Table 18. Under the counterfactual distribution of couples, we find a participation own-wage elasticity of 0.63,

[28]Data for the population shares of couples in 1980 comes from 5% sample of the 1980 Census IPUMS-USA.

Table 18: Labor supply elasticities under counterfactual distribution of couples

Population share	**2000**	**1980**
Homogamy-low	0.60	0.72
Heterogamy-husband high	0.11	0.12
Heterogamy-Wife high	0.09	0.04
Homogamy-high	0.20	0.12
Participation elasticity	**Benchmark**	**Counterfactual**
own-wage	0.56	0.63
Husband's wage	-0.13	-0.11
Non-labor income	-0.006	-0.004

a participation cross-wage elasticity of -0.11 and a participation non-labor income of -0.004. This implies that, although compositional changes do not have a considerable effect on the participation cross-wage and on the participation non-labor income elasticities of married women, the change in the composition of couples accounts for a decline in the participation own-wage elasticity of married women from 0.63 to 0.56. This result suggests that the increase in the educational attainment level of married women during the recent decades has resulted in reduced responsiveness to changes in their wages. Nonetheless, quantifying the role of compositional changes on the labor supply responsiveness of married women requires a more detailed analysis.

7 Concluding Remarks

In this paper, we focus on the static labor supply decision of couples along the extensive margin. Using data from the 2000 U.S. Census, we estimate labor supply elasticities for married women and men by allowing for the heterogeneity among couples in educational attainments of husbands and wives and by modeling the way that household members make their labor supply decisions.

We find that labor supply decisions of husbands and wives depend on each other, unless both spouses are highly educated. For highly educated couples, labor supply decisions of the husband and the wife are jointly determined only if they have preschool age children. We also find that labor supply elasticities differ greatly among different types of households. Allowing for heterogeneity among couples yields an overall participation wage elasticity of 0.56, a cross-wage elasticity of -0.13 and a non-labor income elasticity of -0.006 for married women. Our analysis shows that ignoring the heterogeneity among couples results in a smaller estimate for labor supply own-wage elasticity for married women (about 0.27). We show that taking into account heterogeneity among couples in educational attainments of husbands and wives has an important impact on the elasticity estimates. We find that by only taking into account the heterogeneity among couples in spouses' educational attainments results in a larger elasticity estimate for married women (about 0.48).

The results of this study have important implications for policy analysis. Since many public policies are designed to target specific groups, it is essential to understand potential impacts of policies on the labor supply of different individuals. While earlier studies have focused on heterogeneity associated with the presence of pre-school age children, we show that the variation in the responses of married women depending on the spouses' education levels is present, independent of whether children are present in the household or not. The analysis in this paper also provides a natural framework to study how changes in educational attainments and household structure affect aggregate labor supply elasticities. Our analysis indicates that if married women had the responsiveness of 2000 but the distribution of couples was the same as in 1980, the overall labor supply own-wage elasticity of married women would be 0.63 instead of 0.56.

We conclude by commenting on three important issues we have abstracted from which might be important for future research. First, we have abstracted from fertility decisions, which can be viewed as a shortcoming of our analysis. Although we control for the presence of children in our analysis, earlier work suggest that the decision to have children and the labor supply decision may be interdependent (e.g. Rosenzweig and Wolpin 1980; Angrist and Evans 1998). The second issue pertains to the role of the increase in assortative mating and the changing composition of families and their interplay with labor supply elasticities. Our analysis in Section 6 is a preliminary first step in this direction. Finally, we have not addressed life-cycle and dynamic issues. The dynamic extension of the family labor supply model would make it possible to analyze variations in the family labor supply behavior of different types of couples over the life cycle. We leave this extension for future research.

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Appendices

Appendix A. Simultaneous Probit Model

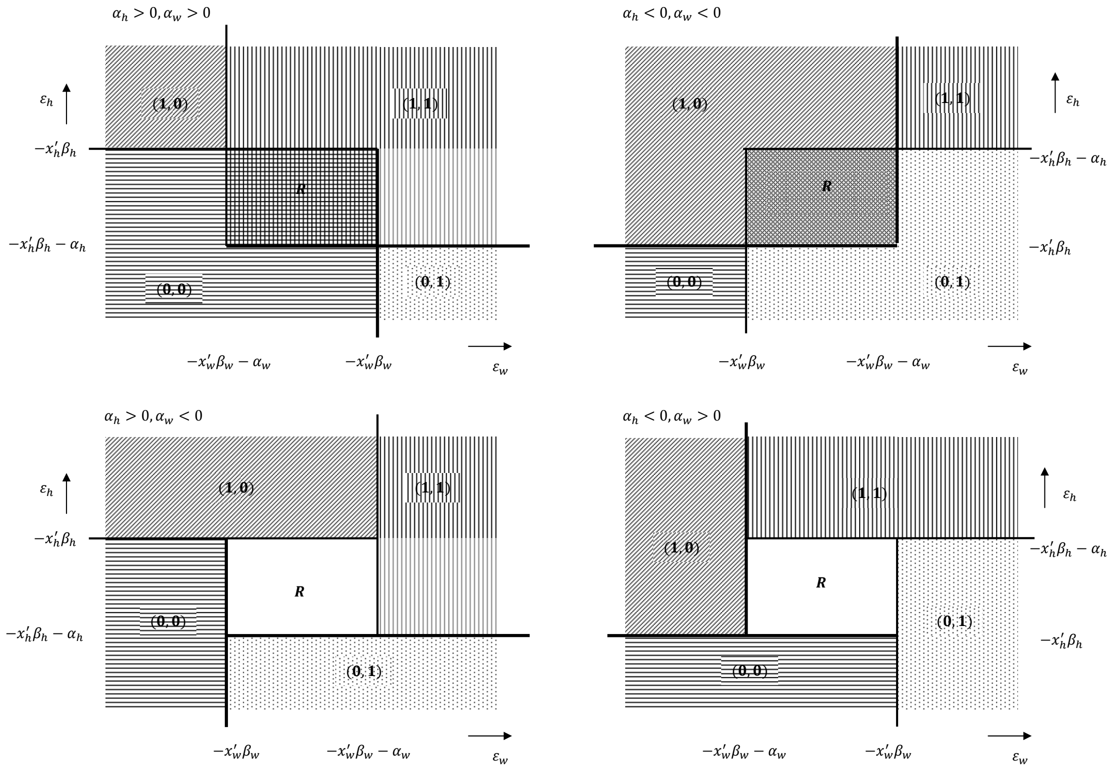

Figure A.1: This figure depicts the possible outcomes when the conditions on the random components in the simultaneous binary model are satisfied. Each panel illustrates a different case for the signs of the parameters α_h and α_w. The region R in each panel corresponds to the region where the model is *incoherent* or *incomplete*. In the top left panel this region is the intersection of $(y_h, y_w) = (0, 0)$ and $(y_h, y_w) = (1, 1)$, and in the top right panel this is the intersection of $(y_h, y_w) = (1, 0)$ and $(y_h, y_w) = (0, 1)$. In the bottom panels, regions R indicate no solution for (y_h, y_w)

Appendix B. Nash Model

Outcome Probabilities in terms of Reaction Functions

$$\begin{aligned}
\Pr(0,0) &= \Pr(H_1,W_1)+\Pr(H_1,W_2)+\Pr(H_2,W_1)\\
&+ a_1\Pr(H_2,W_2)+c_1\Pr(H_2,W_3)+d_1\Pr(H_3,W_2)\\
\Pr(1,0) &= \Pr(H_3,W_1)+\Pr(H_4,W_1)+\Pr(H_4,W_3)\\
&+ b_1\Pr(H_3,W_3)+c_2\Pr(H_2,W_3)+d_2\Pr(H_3,W_2)\\
\Pr(0,1) &= \Pr(H_1,W_3)+\Pr(H_1,W_4)+\Pr(H_3,W_4)\\
&+ a_2\Pr(H_3,W_3)+c_3\Pr(H_2,W_3)+d_3\Pr(H_3,W_2)\\
\Pr(1,1) &= \Pr(H_2,W_4)+\Pr(H_4,W_2)+\Pr(H_4,W_4)\\
&+ b_2\Pr(H_2,W_2)+c_4\Pr(H_2,W_3)+d_4\Pr(H_3,W_2)
\end{aligned}$$

Outcome Probabilities in terms of Model Parameters

If $\alpha_h \geq 0$ and $\alpha_w \geq 0$, then

$$\begin{aligned}
\Pr(0,0) &= \Phi(-x_h'\beta_h,-x_w'\beta_w,\rho)-a_1I(-x_h'\beta_h,-x_w'\beta_w,-x_h'\beta_h-\alpha_h,-x_w'\beta_w-\alpha_w,\rho)\\
\Pr(1,0) &= \Phi(x_h'\beta_h,-x_w'\beta_w-\alpha_w,-\rho)\\
\Pr(0,1) &= \Phi(-x_h'\beta_h-\alpha_h,x_w'\beta_w,-\rho)\\
\Pr(1,1) &= \Phi(x_h'\beta_h+\alpha_h,x_w'\beta_w+\alpha_w,\rho)-a_1I(-x_h'\beta_h,-x_w'\beta_w,-x_h'\beta_h-\alpha_h,-x_w'\beta_w-\alpha_w,\rho)
\end{aligned}$$

If $\alpha_h \geq 0$ and $\alpha_w < 0$, then

$$\begin{aligned}
\Pr(0,0) &= \Phi(-x_h'\beta_h,-x_w'\beta_w,\rho)+c_1I(-x_h'\beta_h,-x_w'\beta_w-\alpha_w,-x_h'\beta_h-\alpha_h,-x_w'\beta_w,\rho)\\
\Pr(1,0) &= \Phi(x_h'\beta_h,-x_w'\beta_w-\alpha_w,-\rho)+c_2I(-x_h'\beta_h,-x_w'\beta_w-\alpha_w,-x_h'\beta_h-\alpha_h,-x_w'\beta_w,\rho)\\
\Pr(0,1) &= \Phi(-x_h'\beta_h-\alpha_h,x_w'\beta_w,-\rho)+c_3I(-x_h'\beta_h,-x_w'\beta_w-\alpha_w,-x_h'\beta_h-\alpha_h,-x_w'\beta_w,\rho)\\
\Pr(1,1) &= \Phi(x_h'\beta_h+\alpha_h,x_w'\beta_w+\alpha_w,\rho)+c_4I(-x_h'\beta_h,-x_w'\beta_w-\alpha_w,-x_h'\beta_h-\alpha_h,-x_w'\beta_w,\rho)
\end{aligned}$$

If $\alpha_h < 0$ and $\alpha_w \geq 0$, then

$$
\begin{aligned}
\Pr(0,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) + d_1 I(-x_h^{'}\beta_h - \alpha_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, \rho) \\
\Pr(1,0) &= \Phi(x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, -\rho) + d_2 I(-x_h^{'}\beta_h - \alpha_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, \rho) \\
\Pr(0,1) &= \Phi(-x_h^{'}\beta_h - \alpha_h, x_w^{'}\beta_w, -\rho) + d_3 I(-x_h^{'}\beta_h - \alpha_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, \rho) \\
\Pr(1,1) &= \Phi(x_h^{'}\beta_h + \alpha_h, x_w^{'}\beta_w + \alpha_w, \rho) + d_4 I(-x_h^{'}\beta_h - \alpha_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, \rho)
\end{aligned}
$$

If $\alpha_h < 0$ and $\alpha_w < 0$, then

$$
\begin{aligned}
\Pr(0,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
\Pr(1,0) &= \Phi(x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, -\rho) - b_2 I(-x_h^{'}\beta_h - \alpha_h, -x_w^{'}\beta_w - \alpha_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
\Pr(0,1) &= \Phi(-x_h^{'}\beta_h - \alpha_h, x_w^{'}\beta_w, -\rho) - b_1 I(-x_h^{'}\beta_h - \alpha_h, -x_w^{'}\beta_w - \alpha_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
\Pr(1,1) &= \Phi(x_h^{'}\beta_h + \alpha_h, x_w^{'}\beta_w + \alpha_w, \rho)
\end{aligned}
$$

where $\Phi(a, b, \rho)$ is the cumulative distribution function evaluated at (a, b) of a bivariate standard normal distribution with correlation ρ, $I(a, b, c, d, \rho)$ is the integral of the corresponding density over the range $a \geq \varepsilon_h$, $b \geq \varepsilon_w$ and

$$
\begin{aligned}
a_1 + a_2 = 1 \quad & c_1 + c_2 + c_3 + c_4 = 1 \\
b_1 + b_2 = 1 \quad & d_1 + d_2 + d_3 + d_4 = 1.
\end{aligned}
$$

Note that in the text it is assumed that $a_i = 1/2$, $b_i = 1/2$ for $i = 1, 2$, and $c_i = 1/4$, $d_i = 1/4$ for $i = 1, 2, 3, 4$ (See Bjorn and Vuong, 1984).

Appendix C. Stackelberg Wife Leader Model

Outcome Probabilities in terms of Husband's Reaction Functions and Wife's Utility Comparisons

$$\begin{aligned}
\Pr(0,0) &= \Pr(H_1, \overline{S_1}) + \Pr(H_2, \overline{S_2}) \\
\Pr(1,0) &= \Pr(H_3, \overline{S_3}) + \Pr(H_4, \overline{S_4}) \\
\Pr(0,1) &= \Pr(H_1, S_1) + \Pr(H_3, S_3) \\
\Pr(1,1) &= \Pr(H_2, S_2) + \Pr(H_4, S_4)
\end{aligned}$$

Outcome Probabilities in terms of Model Parameters

If $\alpha_h \geq 0$, then

$$\begin{aligned}
\Pr(0,0) &= \Phi(-x_w^{'}\beta_w, -x_h^{'}\beta_h, \rho) \\
&- I(-x_w^{'}\beta_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w^1, -x_h^{'}\beta_h - \alpha_h, \rho) \\
\Pr(1,0) &= \Phi(-x_w^{'}\beta_w - \alpha_w^1 + \alpha_w^0, x_h^{'}\beta_h, -\rho) \\
\Pr(0,1) &= \Phi(x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h, -\rho) \\
\Pr(1,1) &= \Phi(x_w^{'}\beta_w + \alpha_w^1 - \alpha_w^0, x_h^{'}\beta_h + \alpha_h, \rho) \\
&- I(-x_w^{'}\beta_w - \alpha_w^1, -x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w^1 + \alpha_w^0 - \alpha_w, -x_h^{'}\beta_h - \alpha_h, \rho)
\end{aligned}$$

otherwise

$$\begin{aligned}
\Pr(0,0) &= \Phi(-x_w^{'}\beta_w, -x_h^{'}\beta_h, \rho) \\
\Pr(1,0) &= \Phi(-x_w^{'}\beta_w - \alpha_w^1 + \alpha_w^0, x_h^{'}\beta_h, -\rho) \\
&+ I(-x_w^{'}\beta_w + \alpha_w^0, -x_h^{'}\beta_h - \alpha_h, -x_w^{'}\beta_w - \alpha_w^1 + \alpha_w^0, -x_h^{'}\beta_h, \rho) \\
\Pr(0,1) &= \Phi(x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h, -\rho) \\
&+ I(-x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h, -x_w^{'}\beta_w + \alpha_w^0, -x_h^{'}\beta_h - \alpha_h, \rho) \\
\Pr(1,1) &= \Phi(x_w^{'}\beta_w + \alpha_w^1 - \alpha_w^0, x_h^{'}\beta_h + \alpha_h, \rho)
\end{aligned}$$

where $\Phi(a, b, \rho)$ is the cumulative distribution function evaluated at (a, b) of a bivariate standard normal distribution with correlation ρ, $I(a, b, c, d, \rho)$ is the integral of the corresponding density over the range $a \geq \varepsilon_w$, $b \geq \varepsilon_h$.

Appendix D. Stackelberg Husband Leader Model

Table D.1: Wife's reaction functions

Reaction function	Utility comparison	Condition
W_1: $y_w = 0$ if $y_h = 0$ and $y_w = 0$ if $y_h = 1$	$U_w(0,1) < U_w(0,0)$ and $U_w(1,1) < U_w(1,0)$	$\varepsilon_w < -x_w^{'}\beta_w - \max(0, \alpha_w)$
W_2: $y_w = 0$ if $y_h = 0$ and $y_w = 1$ if $y_h = 1$	$U_w(0,1) < U_w(0,0)$ and $U_w(1,1) > U_w(1,0)$	$-x_w^{'}\beta_w - \alpha_w < \varepsilon_w < -x_w^{'}\beta_w$ if $\alpha_w > 0$
W_3: $y_w = 1$ if $y_h = 0$ and $y_w = 0$ if $y_h = 1$	$U_w(0,1) > U_w(0,0)$ and $U_w(1,1) < U_w(1,0)$	$-x_w^{'}\beta_w < \varepsilon_w < -x_w^{'}\beta_w - \alpha_w$ if $\alpha_w < 0$
W_4: $y_w = 1$ if $y_h = 0$ and $y_w = 1$ if $y_h = 1$	$U_w(0,1) > U_w(0,0)$ and $U_w(1,1) > U_w(1,0)$	$-x_w^{'}\beta_w - \min(0, \alpha_w) < \varepsilon_w$

Table D.2: Husband's utility comparisons

Reaction function for the wife	Utility comparison for the husband	Condition
W_1	C_1: $U_h(1,0) > U_h(0,0)$	$\varepsilon_h > -x_h^{'}\beta_h$
W_2	C_2: $U_h(1,1) > U_h(0,0)$	$\varepsilon_h > -x_h^{'}\beta_h - \alpha_h^1$
W_3	C_3: $U_h(1,0) > U_h(0,1)$	$\varepsilon_h > -x_h^{'}\beta_h - \alpha_h^0$
W_4	C_4: $U_h(1,1) > U_h(0,1)$	$\varepsilon_h > -x_h^{'}\beta_h - \alpha_h$

Table D.3: Stackelberg Equilibria

W_1 and C_1	(1,0)	W_3 and C_3	(1,0)
W_1 and $\overline{C_1}$	(0,0)	W_3 and $\overline{C_3}$	(0,1)
W_2 and C_2	(1,1)	W_4 and C_4	(1,1)
W_2 and $\overline{C_2}$	(0,0)	W_4 and $\overline{C_4}$	(0,1)

Outcome Probabilities in terms of Wife's Reaction Functions and Husband's Utility Comparisons

$$
\begin{aligned}
\Pr(0,0) &= \Pr(\overline{C_1}, W_1) + \Pr(\overline{C_2}, W_2) \\
\Pr(1,0) &= \Pr(C_1, W_1) + \Pr(C_3, W_3) \\
\Pr(0,1) &= \Pr(\overline{C_3}, W_3) + \Pr(\overline{C_4}, W_4) \\
\Pr(1,1) &= \Pr(C_2, W_2) + \Pr(C_4, W_4)
\end{aligned}
$$

Outcome Probabilities in terms of Model Parameters

If $\alpha_w \geq 0$, then

$$
\begin{aligned}
\Pr(0,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
&- I(-x_h^{'}\beta_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w, \rho) \\
\Pr(1,0) &= \Phi(x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, -\rho) \\
\Pr(0,1) &= \Phi(-x_h^{'}\beta_h - \alpha_h^1 + \alpha_h^0, x_w^{'}\beta_w, -\rho) \\
\Pr(1,1) &= \Phi(x_h^{'}\beta_h + \alpha_h^1 - \alpha_h^0, x_w^{'}\beta_w + \alpha_w, \rho) \\
&- I(-x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1 + \alpha_h^0 - \alpha_h, -x_w^{'}\beta_w - \alpha_w, \rho)
\end{aligned}
$$

otherwise

$$
\begin{aligned}
\Pr(0,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
\Pr(1,0) &= \Phi(x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, -\rho) \\
&+ I(-x_h^{'}\beta_h, -x_w^{'}\beta_w - \alpha_w, -x_h^{'}\beta_h + \alpha_h^0, -x_w^{'}\beta_w - \alpha_w, \rho) \\
\Pr(0,1) &= \Phi(-x_h^{'}\beta_h - \alpha_h^1 + \alpha_h^0, x_w^{'}\beta_w, -\rho) \\
&+ I(-x_h^{'}\beta_h + \alpha_h^0, -x_w^{'}\beta_w - \alpha_w, -x_h^{'}\beta_h - \alpha_h^1 + \alpha_h^0, -x_w^{'}\beta_w, \rho) \\
\Pr(1,1) &= \Phi(x_h^{'}\beta_h + \alpha_h^1 - \alpha_h^0, x_w^{'}\beta_w + \alpha_w, \rho)
\end{aligned}
$$

where $\Phi(a, b, \rho)$ is the cumulative distribution function evaluated at (a, b) of a bivariate standard normal distribution with correlation ρ, $I(a, b, c, d, \rho)$ is the integral of the corresponding density over the range $a \geq \varepsilon_h$, $b \geq \varepsilon_w$ (See Bjorn and Vuong, 1985).

Appendix E. Nash/Pareto optimality Model

Outcome Probabilities in terms of Model Parameters

If $\alpha_h^0 - \alpha_h^1 >= 0$ and $\alpha_w^0 - \alpha_w^1 >= 0$:

$$
\begin{aligned}
\Pr(1,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -\rho) \\
&- \frac{1}{2} I(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
\Pr(1,1) &= \Phi(x_h^{'}\beta_h - \alpha_h^0 + \alpha_h^1, x_w^{'}\beta_w - \alpha_w^0 + \alpha_w^1, \rho) \\
&+ I(-x_h^{'}\beta_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w^1, \rho) \\
\Pr(0,1) &= \Phi(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, -\rho) \\
&- \frac{1}{2} I(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
\Pr(0,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
&- I(-x_h^{'}\beta_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w^1, \rho)
\end{aligned}
$$

If $\alpha_h^0 - \alpha_h^1 >= 0$ and $\alpha_w^0 - \alpha_w^1 < 0$:

$$
\begin{aligned}
\Pr(1,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -\rho) \\
\Pr(1,1) &= \Phi(x_h^{'}\beta_h - \alpha_h^0 + \alpha_h^1, x_w^{'}\beta_w - \alpha_w^0 + \alpha_w^1, \rho) \\
&+ I(-x_h^{'}\beta_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w^1, \rho) \\
&+ \frac{1}{2} I(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, \rho) \\
\Pr(0,1) &= \Phi(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, -\rho) \\
&+ \frac{1}{2} I(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, -x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, \rho) \\
\Pr(0,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
&- I(-x_h^{'}\beta_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w^1, \rho)
\end{aligned}
$$

If $\alpha_h^0 - \alpha_h^1 < 0$ and $\alpha_w^0 - \alpha_w^1 >= 0$:

$$
\begin{aligned}
\Pr(1,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -\rho) \\
&+ \frac{1}{2} I(-x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, \rho) \\
\Pr(1,1) &= \Phi(x_h^{'}\beta_h - \alpha_h^0 + \alpha_h^1, x_w^{'}\beta_w - \alpha_w^0 + \alpha_w^1, \rho) \\
&+ I(-x_h^{'}\beta_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w^1, \rho) \\
&+ \frac{1}{2} I(-x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, \rho) \\
\Pr(0,1) &= \Phi(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, -\rho) \\
\Pr(0,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
&- I(-x_h^{'}\beta_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w^1, \rho)
\end{aligned}
$$

If $\alpha_h^0 - \alpha_h^1 < 0$ and $\alpha_w^0 - \alpha_w^1 < 0$:

$$
\begin{aligned}
\Pr(1,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -\rho) \\
\Pr(1,1) &= \Phi(x_h^{'}\beta_h - \alpha_h^0 + \alpha_h^1, x_w^{'}\beta_w - \alpha_w^0 + \alpha_w^1, \rho) \\
&+ I(-x_h^{'}\beta_h, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w^1, \rho) \\
&+ I(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w + \alpha_w^0 - \alpha_w^1, \rho) \\
\Pr(0,1) &= \Phi(-x_h^{'}\beta_h + \alpha_h^0 - \alpha_h^1, -x_w^{'}\beta_w, -\rho) \\
\Pr(0,0) &= \Phi(-x_h^{'}\beta_h, -x_w^{'}\beta_w, \rho) \\
&- I(-x_h^{'}\beta_h, -x_w^{'}\beta_w, -x_h^{'}\beta_h - \alpha_h^1, -x_w^{'}\beta_w - \alpha_w^1, \rho)
\end{aligned}
$$

where $\Phi(a, b, \rho)$ is the cumulative distribution function evaluated at (a, b) of a bivariate standard normal distribution with correlation ρ and $I(a, b, c, d, \rho)$ is the integral of the corresponding density over the range $a \geq \varepsilon_h$, $b \geq \varepsilon_w$.

Table E.1: Nash/Pareto optimality ($\alpha_h^1 > 0$, $\alpha_h^0 > 0$, $\alpha_w^1 > 0$ and $\alpha_w^0 > 0$)

Husband/Wife	$U_w(0,0) < U_w(1,0) < U_w(0,1) < U_w(1,1)$	$U_w(0,0) < U_w(0,1) < U_w(1,0) < U_w(1,1)$	$U_w(0,1) < U_w(0,0) < U_w(1,0) < U_w(1,1)$	$U_w(0,0) < U_w(0,1) < U_w(1,1) < U_w(1,0)$	$U_w(0,1) < U_w(0,0) < U_w(1,1) < U_w(1,0)$	$U_w(0,1) < U_w(1,1) < U_w(0,0) < U_w(1,0)$
$U_h(0,0) < U_h(1,0) < U_h(0,1) < U_h(1,1)$	(1,1)	(1,1)	(1,1)	(1,0)	(1,0)	(1,0)
$U_h(0,0) < U_h(0,1) < U_h(1,0) < U_h(1,1)$	(1,1)	(1,1)	(1,1)	(1,0)	(1,0)	(1,0)
$U_h(0,1) < U_h(0,0) < U_h(1,0) < U_h(1,1)$	(1,1)	(1,1)	(1,1)	(1,1) and (1,0)	(1,1)	(0,0)
$U_h(0,0) < U_h(0,1) < U_h(1,1) < U_h(1,0)$	(0,1)	(0,1)	(1,1) and (0,1)	(1,0) and (0,1)	(1,0)	(1,0)
$U_h(0,1) < U_h(0,0) < U_h(1,1) < U_h(1,0)$	(0,1)	(0,1)	(1,1)	(0,1)	(1,1)	(0,0)
$U_h(0,1) < U_h(1,1) < U_h(0,0) < U_h(1,0)$	(0,1)	(0,1)	(0,0)	(0,1)	(0,0)	(0,0)

Appendix F. Labor Supply Elasticities of Married Men

Table F.1: Labor supply elasticities of married men by type of couples

	Own wage	**Wife's wage**	**Non-labor income**
Homogamy-low	0.04	0.01	0.000
	(0.000)	(0.000)	(0.000)
Heterogamy-husband high	0.02	0.02	0.000
	(0.000)	(0.000)	(0.000)
Heterogamy-wife high	0.06	-0.02	0.000
	(0.000)	(0.000)	(0.000)
Homogamy-high	0.05	-0.01	0.000
	(0.000)	(0.000)	(0.000)
All	0.04	0.00	0.000

Note: Standard errors in parenthesis.