The Role of Relative Prices in Explaining Differences in Female Labor Supply Behavior

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1 Introduction

Over the last forty years, there has been a dramatic increase in female labor supply in most developed countries. A combination of factors have contributed to this increase. Women have been gaining more education, thus increasing their productivity and hence the opportunity cost of time spent outside the market. While participation rates for single women have always been high, those for married women have increased substantially over this period. Women are choosing to marry and have children later in life, which allows them to build up labor market experience, and hence earnings potential, before they make these decisions. This has increased women’s attachment to the labor force and made women more likely to remain in the labor force following marriage and more likely to return to the labor force after childbirth than ever before. On the demand side, the last forty years has seen a sectoral shift in employment away from labor intensive manufacturing and agriculture sectors towards gender neutral service sectors, which has increased the demand for women in the labor force.

In the United States, the participation rate for prime aged women increased from just around 40 percent in 1960 to over 75 percent by 2000. Figure 1 shows that a similar pattern has emerged in many developed countries over the same time period. While the speed and timing of the increase varies across countries, the general trend of increasing participation is obvious.

This trend cannot continue indefinitely. Full participation is an obvious upper bound, but it is unlikely that female labor force participation rates will ever come close to this. Data for male labor force participation rates in the countries of Figure 1 fluctuate between 85 and 95

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percent over the entire period. There appears to have been some convergence in recent years, with all countries reporting male participation rates between 85 and 90 percent since the year 2000. Although an increasing number of women are active participants in labor markets and their attachment to the labor force has strengthened over time, the female labor force participation rate is unlikely to reach that for men. Participation rates for married women and for women with children remain below those for single women without children as many women continue to exit the labor force and specialize in home production following marriage and/or childbirth. Indeed, there is some evidence from Figure 1 that female participation rates have levelled off in recent years in the US, France, Germany and the UK. One possible interpretation of the data in Figure 1 is that these countries have reached some natural upper bound for female participation rates, which appears to be between 75 and 80 percent. Other countries, such as Ireland, Spain, Greece and Italy, appear to still be on a convergence path.

Figure 1: Female Labor Force Participation Rates, Ages 25-54.

This raises two questions: what caused participation to increase over this period, and why are there persistent differentials between countries? While many studies offer different explanations for the increase in participation rates within individual countries, none have addressed perhaps the most basic question: are the observed patterns of female labor supply
simply the result of a representative woman responding to different relative prices over time and across countries? In this paper, I will attempt to answer this question using variation over time within the US. Cross-country variation will be examined in future work.

I develop a simple model of female labor supply, with preferences estimated using microdata from the US that spans the time period under consideration (1968 through 2000). According to the model, a woman will choose to work if her after-tax market wage (or demand price) exceeds her reservation wage (or supply price) at zero hours of work. The market wage is assumed to be determined by educational attainment and labor market experience, which is proxied using age. The reservation wage is derived from the model to be a function of non-labor income, marital status and number of children. Conditional on participation, her optimal hours choice then adjusts until these prices are equalized. I pool data from eight waves of the Current Population Survey from 1968 to 2000 and estimate a single set of preference parameters for all women, while allowing the parameters of the wage equation to vary over time. Using the after-tax wage rate as a proxy for the price of leisure, I can then see how much of the observed increase in labor supply can be accounted for using only changes in the structure of wages over time.

The results show a significant role for wages, non-labor income and household characteristics such as marital status and number of children in determining the labor supply decisions of women. I estimate an uncompensated wage elasticity of around 0.4, while non-labor income, being married and the presence of children all increase the reservation wage and reduce optimal hours worked. The model matches the observed participation rates quite well for recent years, and it does match the trend of increasing participation over time. However, it significantly overpredicts the participation rate in the earlier years when participation was lowest. The model predicts an increase of 20% in participation rates between 1968 and 2000, compared to a 73% increase observed in the data. I also perform some counterfactuals by “moving” a woman between different time periods. Imposing the wage parameters estimated for 2000 on the sample of women from 1968, holding all taxes constant, the participation rate in 1968 would have been 11% higher.

The next section provides a brief overview of related studies. Section 3 develops a simple model of female labor supply in the presence of taxes. The data used for estimation is described in Section 4, while Section 5 sets out a framework for estimation. The results and some counterfactuals are presented in Section 6. Section 7 outlines the incorporation of fixed
costs to the current model in order to explain the peaks in the hours distribution around 0 and 40 hours per week. The final section concludes and discusses some avenues for future work.

2 Background

The dramatic increase in female labor force participation rates over time and across countries has not gone unnoticed in the literature. The Journal of Labor Economics published a special issue in 1985 entitled “Trends in Women’s Work, Education, and Family Building”, which contained a series of studies from twelve industrialized countries explaining the increase in female participation rates between 1960 and 1980. Mincer (1985) collects the results of these papers and discusses declining fertility, increasing divorce rates, growth of real wages, narrowing of the male/female wage gap and increasing educational attainment as potential explanations for the increase in participation, most notably by married women. Smith and Ward (1985) consider the effects that rising real wages have had on female labor supply between the end of World War 2 and 1981 and find that real wage growth can account for 60% of the growth in the female labor force, with half of this effect due to the fertility reducing consequences of a higher female wage. The other individual papers are mostly descriptive in nature, employing probits to determine the effects of certain characteristics on labor supply. However, there is no unifying framework across countries, making accurate cross-country comparisons difficult. My paper currently only considers changes over time within the US, but it provides a framework that can be easily extended to include cross-country comparisons. This will allow me to examine whether the data can be interpreted as the same representative agent responding to different relative prices across countries.

There has been more recent work using aggregate data in the macroeconomics literature that attempts to explain increases in labor supply. Jones et al. (2003) find that reductions in the gender wage gap can explain significant increases in the average hours worked by married women and the relative constancy in the hours worked by single women and all men. Greenwood et al. (2005) find that technological progress can explain some of the growth in participation since 1900. Prescott (2004) finds that tax rates alone can account for most of the differences in labor supply (measured as hours worked per person) across industrialized countries. This paper will look at effects of wages and taxes at the household level to explain part of this gap, since participation is only one part of the total amount of work being done.
3 Model

The starting point is the canonical model of labor supply. Individuals maximize a twice differentiable utility function subject to a budget constraint $C = E + Y$, where $C$ is consumption of a composite commodity, $Y$ is non-labor income and $E$ is gross earnings, with $E = Wh$ for a given gross wage rate, $W$, and hours of work, $h$. Utility is increasing in $C$ and decreasing in labor supply, $h$. In the absence of taxes, labor supply is given by $h^*(W,Y,v)$, where $v$ represents individual preferences unobserved by the economist. For many women, their optimal labor supply choice is zero hours. This occurs if the marginal rate of substitution between consumption and hours worked (often referred to as the shadow or supply price of the woman’s time) exceeds the market wage rate (or the demand price) at zero hours of work. This shadow price can be estimated at both interior and corner solutions, which provides a simple framework for estimating the preference parameters governing who will work and how much they choose to work (Heckman, 1974). Conditional on the shadow price exceeding the market wage at zero hours, a woman will choose to work in equilibrium, and her optimal hours adjust until her marginal rate of substitution equals her market wage.

According to the Statistical Abstract of the United States, almost 130 million people filed tax returns in 2000, with an average payment of $8,879 from an average Adjusted Gross Income of $49,202. Obviously the tax burden varies considerably with earnings, but this highlights the fact that the tax system introduces a significant wedge between gross and net earnings. A realistic model of female labor supply should account for the distortions introduced by these taxes. In this paper I adopt the methods set out by MaCurdy et al. (1990) to model the taxation system, which involves approximating the non-linear budget constraint resulting from the taxation system using a smooth differentiable function.

There is a vast literature that analyzes labor supply in the presence of taxes. Blundell and MaCurdy (1999) provide an encyclopaedic overview. In short, the structure of the taxation system introduces multiple kinks and non-convex portions to the budget constraint. There are two principal approaches for dealing with this additional complexity. The first constructs a piecewise linear budget constraint for each individual, with kinks occurring as the individual moves between tax brackets. The second and simpler approach approximates the marginal tax rate, a step function, using a smooth differentiable function that summarizes

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1 Non-labor income is modeled as husband’s gross earnings in this paper.
the different tax brackets. I adopt this approach and use the NBER’s TAXSIM model to simulate the budget constraint facing each individual.\textsuperscript{2} The tax burden facing a household and the woman’s marginal tax rate are computed using TAXSIM. The TAXSIM program estimates both federal and state tax burdens and marginal rates from 1980 onwards, but only federal taxes before 1980. Since three of my eight samples used in the estimation are pre-1980, I only use the federal tax burden and marginal rate for estimation to ensure comparability across samples.

The presence of taxes changes the budget constraint to $C = E + Y - T(Y, E)$, where the tax function $T$ is assumed to be twice differentiable in $E$. MaCurdy et al. show that approximating the tax schedule using a differentiable function leads to a much simpler approach for developing an empirical model of labor supply that recognizes the influence of taxes, compared to the piecewise linear approach often used elsewhere in the literature. Given such a smooth differentiable tax function, the budget constraint is illustrated in black in Figure 2.

This allows us to define the following variables:

$$
\begin{align*}
\tau(Y, E) &= \tau(Y, Wh) = \frac{\partial T}{\partial E} \\
w(h) &= [1 - \tau]W = [1 - \tau(Y, Wh)]W \\
y(h) &= Y + E - [1 - \tau]E - T \\
&= Y + [\tau(Y, Wh)]Wh - T(Y, Wh)
\end{align*}
$$

where $\tau$ is the marginal tax rate on earnings, $w(h)$ is the marginal wage at $h$ hours of work with $\tau$ evaluated at $Y$ and $E$, and $y(h)$ represents virtual income evaluated at the same combination of $Y$ and $E$.

The situation depicted in Figure 2 illustrates the budget constraint of an individual facing a non-linear tax system. The tax function is then approximated using a linear constraint (the gray line) that is constructed to be tangent to the actual non-linear function at the individuals optimal choice of hours worked ($h$). Thus, the implied slope of both the linear and non-linear functions is $w(h)$ and the relevant non-labor income is $y(h)$.

So if an individual does not work, then:

$$h^*(w(0), y(0), v) \leq 0$$

\textsuperscript{2}TAXSIM is the NBER’s FORTRAN program for calculating liabilities under US Federal and State income tax laws from individual data. See http://www.nber.org/taxsim/ for more details.
Otherwise, hours worked are strictly positive and satisfy the implicit equation:

\[ h = h^*(w(h), y(h), v) \]

Taxes enter this labor supply function through the \( w(h) \) and \( y(h) \) terms, which were defined above and represent the after tax wage and non-labor income facing each working woman.

4 Data

The data used in this study come from multiple waves of the US Current Population Survey (CPS), since these datasets contain detailed information regarding family structure and income. Variation in participation rates over time is analyzed using eight waves of the CPS spanning the period 1968 to 2000.\(^3\) All income data is converted into 1999 dollars, since the 2000 CPS asks questions about hours and income for the previous year. For older waves of the CPS the Consumer Price Index is used to index all wage and income data. I only consider women aged between 25 and 54, so that educational attainment has already been determined, but the retirement decision is not yet relevant. Finally, \( LFP \) is an indicator variable for participation which equals one if the woman reported strictly positive hours of work in the survey.\(^4\) The means of the relevant variables used for estimation are described


\(^{4}\)Note that the CPS asks the respondent how many hours they worked each week over the previous year between 1976 and 2000. Prior to 1976, the only available measure of labor supply was the number of hours worked in the previous week.
in Table 1, with standard deviations in parentheses. This table highlights the main differences in these variables over time. Descriptive statistics for all eight waves are given in the Appendix B, while more detail on the construction of these variables is given in Appendix A.

Table 1: Differences Between Working and Non-Working Women.

<table>
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<tr>
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<tbody>
<tr>
<td></td>
<td>LFP=1</td>
<td>LFP=0</td>
<td>LFP=1</td>
<td>LFP=0</td>
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<tr>
<td>Age</td>
<td>39.99</td>
<td>39.06</td>
<td>37.39</td>
<td>38.73</td>
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<td></td>
<td>(8.49)</td>
<td>(8.52)</td>
<td>(8.47)</td>
<td>(8.85)</td>
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<tr>
<td>Years of Education</td>
<td>11.54</td>
<td>11.06</td>
<td>12.57</td>
<td>11.44</td>
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<td></td>
<td>(2.73)</td>
<td>(2.86)</td>
<td>(2.60)</td>
<td>(3.03)</td>
</tr>
<tr>
<td>Number of Children</td>
<td>1.41</td>
<td>2.14</td>
<td>1.30</td>
<td>1.73</td>
</tr>
<tr>
<td></td>
<td>(1.53)</td>
<td>(1.77)</td>
<td>(1.23)</td>
<td>(1.45)</td>
</tr>
<tr>
<td>Proportion Married</td>
<td>0.79</td>
<td>0.93</td>
<td>0.80</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>(0.41)</td>
<td>(0.26)</td>
<td>(0.40)</td>
<td>(0.34)</td>
</tr>
<tr>
<td>Non-Labor Income</td>
<td>492.48</td>
<td>667.16</td>
<td>557.23</td>
<td>647.71</td>
</tr>
<tr>
<td></td>
<td>(548.69)</td>
<td>(580.75)</td>
<td>(550.51)</td>
<td>(654.54)</td>
</tr>
<tr>
<td>Household Tax Burden</td>
<td>105.25</td>
<td>76.42</td>
<td>142.33</td>
<td>93.14</td>
</tr>
<tr>
<td></td>
<td>(113.28)</td>
<td>(112.74)</td>
<td>(160.75)</td>
<td>(131.32)</td>
</tr>
<tr>
<td>Marginal Tax Rate</td>
<td>0.17</td>
<td>0.13</td>
<td>0.23</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.09)</td>
<td>(0.13)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>Weekly Hours Worked</td>
<td>35.16</td>
<td>-</td>
<td>34.97</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(11.27)</td>
<td>(11.10)</td>
<td>(10.75)</td>
<td>(10.63)</td>
</tr>
<tr>
<td>Average Hourly Wage</td>
<td>9.84</td>
<td>-</td>
<td>9.35</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(7.88)</td>
<td>(6.74)</td>
<td>(8.00)</td>
<td>(10.28)</td>
</tr>
<tr>
<td>Observations</td>
<td>9619</td>
<td>11488</td>
<td>19237</td>
<td>9706</td>
</tr>
<tr>
<td>LFP</td>
<td>45.6%</td>
<td>66.5%</td>
<td>74.4%</td>
<td>77.3%</td>
</tr>
</tbody>
</table>

Table 1 also shows that average educational attainment and the average hourly wage have both increased significantly since 1968. The age structure of each sample has remained stable, as has the proportion of women that are married and the average number of children. The participation rates in these samples mirror the steady increase observed in Figure 1, showing a 70% increase in participation between 1968 and 2000. Women that work tend to work full time, with the average weekly hours worked hovering around 35 hours per week and increasing slightly in later surveys.

Table 1 also illustrates the significant differences in personal characteristics between workers and non-workers. On average, working women have more education and fewer children, with these differences significant at the 5% level each year. Non-working women also have significantly higher non-labor income in each sample presented above, which is consistent with the findings of Mroz (1987).

The tax burden and marginal tax rate facing each household is computed using TAXSIM,
under the assumption that all married couples file jointly and claim the standard deduction.\(^5\) Hence, it is possible for a non-working woman to face a very high marginal tax rate if her husband has high earnings. The marginal tax rate facing average working woman in each sample has remained relatively stable over time, while the marginal tax rate facing non-working women has declined significantly. The overall tax burden facing households where the woman works is unsurprisingly higher than that facing households where the woman does not work.

5 Estimation

I adopt a functional form that yields a semilog labor supply function. The main features of this specification are discussed in more detail in Stern (1986), but merits of this specification include straightforward estimation and easy incorporation of variability across households.

Each individual \(i\) maximizes their utility, which is given by:

\[
u(c, h) = e^{\beta w_i} \left[ \alpha \ln w_i + \beta (c_i - w_i h_i) + \gamma_i - \alpha \varepsilon_i \right] - \frac{\alpha}{\beta} E_i(\beta w_i)
\]

where \(E_i(\beta w_i) = \int_{-\infty}^{\beta w_i} e^t dt\). This yields an indirect utility function of the form:

\[
v(w_i, y_i) = e^{\beta w_i} \left[ \alpha \ln w_i + \beta y_i + \gamma_i - \alpha \varepsilon_i \right] - \frac{\alpha}{\beta} E_i(\beta w_i)
\]

Appealing to Roy’s Identity, labor supply is given by:

\[
h_i = \frac{\partial v}{\partial w_i} = \alpha \ln w_i + \beta y_i + \gamma_i - \alpha \varepsilon_i \tag{1}
\]

Individual characteristics enter the labor supply equation through \(\gamma_i\):

\[
\gamma_i = \gamma_0 + \gamma_1 M_i + \gamma_2 K_{18i}
\]

where \(M\) is a dummy variable equal to one if the woman is married and \(K_{18}\) is the number of children under 18 that she has. Both of these are expected to reduce labor supply. The labor supply function in (1) can be manipulated to yield the shadow or supply price of labor for each woman:

\(^5\)This may lead to some over-prediction of the actual tax burden if a household itemizes.
\[ \ln w_i^* = \left[ \frac{h_i - \beta y_i - \gamma_i}{\alpha} \right] + \varepsilon_i \]  \hspace{1cm} (2) 

From Section 3, the relevant \( w_i \) and \( y_i \) are given by

\[ w_i = w(h_i) = [1 - \tau(Y_i, W_i h_i)]W_i \]
\[ y_i = y(h_i) = Y_i + \tau(Y_i, W_i h_i) - T(Y_i, W_i h_i) \]

On the demand side, the market wage is given by a standard Mincerian earnings equation, where the natural log of the hourly wage rate is regressed on education and a quadratic in labor market experience. However, the CPS does not contain any measure of labor market experience, so I use age as a proxy.

\[ \ln w^m_i = b_0 + b_1 S_i + b_2 A_i + b_2 A_i^2 + \eta_i = \hat{\ln} w^m_i + \eta_i \]  \hspace{1cm} (3) 

Here, \( S_i \) represents years of educational attainment, \( A_i \) is age and \( \eta_i \) is an idiosyncratic wage shock that is unobserved by the economist.

In the presence of taxes, women make their participation decisions based on the after-tax wage rather than the gross wage. A woman will choose to work if her after-tax wage exceeds her reservation wage at zero hours of work. This requires:

\[ \ln[(1 - \tau_o)w^m_i] > \ln w_i^* \]
\[ \iff \ln(1 - \tau_o) + \ln w_i^m > \ln w_i^* \]

where \( \tau_o \) is her marginal tax rate when \( h = 0 \). This tax rate at zero hours is easily computed using TAXSIM for each individual. Hence, a woman chooses to participate if:

\[ \ln(1 - \tau_o) + \hat{\ln} w^m_i + \eta_i > \frac{\beta y_i + \gamma_i}{\alpha} + \varepsilon_i \]

\[ \iff \varepsilon_i - \eta_i < \ln(1 - \tau_o) + \hat{\ln} w^m_i + \frac{\beta y_i + \gamma_i}{\alpha} = Z_i \]  \hspace{1cm} (4) 

Conditional on (4) holding, hours then adjust until \( w_i^* = (1 - \tau)w^m_i \). This condition can be solved to derive a worker’s optimal hours choice:

\[ \frac{h_i - \beta y_i - \gamma_i}{\alpha} + \varepsilon_i = \ln(1 - \tau) + \hat{\ln} w^m_i + \eta_i \]
\[ h_i - \beta y_i - \gamma_i + \alpha \varepsilon_i = \alpha \left[ \ln(1 - \tau) + \hat{\ln} w^m_i + \eta_i \right] \]
where $y_i = Y_i + \tau_i E_i - T_i$. Then, (3) and (5) constitute the reduced form to be estimated. Hence, we have:

$$h_i = \hat{h}_i + \alpha(\eta_i - \varepsilon_i)$$

$$\ln w^m_i = \hat{\ln} w^m_i + \eta_i$$

The crucial feature of this model is that we only observe an individual’s hours and wages if they work. Given a sample of working women, the error terms in the above equations are conditional on (4) holding at zero hours. These working women are a non-random sample of the entire population, thus resulting in a sample selection problem. Heckman (1974) sets out a method for obtaining consistent parameter estimates. Following this method, for a sample of $N$ women of which $K$ work, the likelihood function can be written as:

$$L = \prod_{i=1}^{K} n(h_i, \ln w^m_i) \prod_{i=K+1}^{N} \text{Pr}([\ln((1-\tau_o)w^m_i] < \ln w^*_i|h=0)$$

where $n(h_i, \ln w^m_i)$ is the unconditional distribution and $\text{Pr}([\ln((1-\tau_o)w^m_i] < \ln w^*_i|h=0)$ is the probability that a woman works. Then, maximizing this function with respect to the parameters of the model yields consistent, asymptotically unbiased and efficient parameter estimates that are asymptotically normally distributed. The exact derivation of the likelihood contributions of both workers and non-workers is described in detail in Appendix C.

6 Results

The data from all eight waves of the CPS is pooled and used to estimate the parameters. The question of interest is whether the data on female labor supply can be interpreted as the same representative agent responding to different relative prices over time. To answer this question, I estimate one set of preference parameters and allow the parameters from the wage equation to vary over time. The preference parameters are presented in Table 2.

These parameter estimates imply a labor supply function of the form:

$$\hat{h}_i = 7.4037 + 13.2828 \ln w_i - 0.0030 y_i - 3.9891 M_i - 3.3687 K_{18}$$

I use this to compute the uncompensated elasticity of labor supply:

$$\frac{\partial h_i}{\partial w^m_i} \frac{w^m_i}{h_i} = 13.2828 \frac{1}{w_i} \frac{w^m_i}{h_i} = 13.2828 \frac{1}{h_i}$$
Table 2: Preference Parameter Estimates and Standard Errors

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<tbody>
<tr>
<td></td>
<td>$\alpha$</td>
<td>13.2828</td>
<td>(0.1603)</td>
<td>$\sigma^2_\epsilon$</td>
<td>3.3964</td>
<td>(0.0728)</td>
<td>$\beta$</td>
<td>-0.0030</td>
</tr>
<tr>
<td></td>
<td>$\gamma_1$</td>
<td>-3.9891</td>
<td>(0.1883)</td>
<td>$\gamma_2$</td>
<td>-3.3687</td>
<td>(0.0443)</td>
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</table>

For the pooled sample, the mean weekly hours worked is approximately 35. Using this average in the elasticity formula yields an uncompensated labor supply elasticity of around 0.4. This appears to be a reasonable measure when compared to the range of estimates presented in Killingsworth and Heckman (1986). It suggests that a 1% increase in market wages will increase labor supply by 0.4%.

These estimates also point to a significant role for non-labor income and household demographic characteristics in determining labor supply. Non-labor income increases the reservation wage and makes participation less likely, and reduces the optimal hours choice for workers. This is to be expected given that non-labor income was found to be significantly higher for non-workers in the previous section. Holding taxes and earnings constant, an increase of $100 in weekly non-labor income will reduce labor supply by around 20 minutes per week. Being married reduces labor supply by almost 4 hours per week, as does each child under 18 that the woman has. All these parameters are significantly different from zero at a 1% level of significance and have the expected signs.

Table 3: Wage Function Estimates and Standard Errors

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<tr>
<td>$b_0$ Constant</td>
<td>-0.8280</td>
<td>-1.8938</td>
<td>-1.0094</td>
<td>-1.0445</td>
<td>-1.5610</td>
<td>-1.6368</td>
<td>-1.6913</td>
<td>-1.6112</td>
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<tr>
<td></td>
<td>(0.2071)</td>
<td>(0.2148)</td>
<td>(0.1926)</td>
<td>(0.1486)</td>
<td>(0.1521)</td>
<td>(0.1769)</td>
<td>(0.1979)</td>
<td>(0.2169)</td>
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<tr>
<td>$b_1$ Education</td>
<td>0.1112</td>
<td>0.1300</td>
<td>0.1328</td>
<td>0.1252</td>
<td>0.1414</td>
<td>0.1439</td>
<td>0.1485</td>
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<tr>
<td></td>
<td>(0.0033)</td>
<td>(0.0034)</td>
<td>(0.0030)</td>
<td>(0.0024)</td>
<td>(0.0027)</td>
<td>(0.0028)</td>
<td>(0.0029)</td>
<td>(0.0029)</td>
</tr>
<tr>
<td>$b_2$ Age</td>
<td>0.0379</td>
<td>0.0864</td>
<td>0.0421</td>
<td>0.0560</td>
<td>0.0763</td>
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<td>(0.0107)</td>
<td>(0.0110)</td>
<td>(0.0099)</td>
<td>(0.0077)</td>
<td>(0.0080)</td>
<td>(0.0092)</td>
<td>(0.0103)</td>
<td>(0.0111)</td>
</tr>
<tr>
<td>$b_3$ Age$^2$</td>
<td>-0.0003</td>
<td>-0.0010</td>
<td>-0.0005</td>
<td>-0.0007</td>
<td>-0.0009</td>
<td>-0.0010</td>
<td>-0.0009</td>
<td>-0.0010</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
</tr>
</tbody>
</table>

The parameters of the wage functions are allowed to vary over time. The estimates are
presented in Table 3, which shows that the parameters of the wage equation have remained relatively stable over time. The return to one year of additional education is around 13% in each year. The return to age fluctuates across each sample, but in any year a higher return to age or education is associated with a lower constant term. Given one set of preference parameters and the fact that the wage parameters do not vary much over the period under consideration, it is unlikely that this model will be able to explain the increase in participation over time. The predictions of the estimated parameters are shown in Table 4

Table 4: Model Fit

<table>
<thead>
<tr>
<th></th>
<th>Participation Model</th>
<th>Participation Data</th>
<th>Hours Model</th>
<th>Hours Data</th>
<th>Log Wage Model</th>
<th>Log Wage Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>80.5</td>
<td>77.3</td>
<td>23.1</td>
<td>37.1</td>
<td>2.07</td>
<td>2.22</td>
</tr>
<tr>
<td>1995</td>
<td>79.0</td>
<td>75.1</td>
<td>21.8</td>
<td>36.5</td>
<td>1.95</td>
<td>2.12</td>
</tr>
<tr>
<td>1990</td>
<td>77.9</td>
<td>74.4</td>
<td>21.1</td>
<td>36.1</td>
<td>1.89</td>
<td>2.06</td>
</tr>
<tr>
<td>1985</td>
<td>75.4</td>
<td>70.2</td>
<td>18.7</td>
<td>35.4</td>
<td>1.74</td>
<td>1.95</td>
</tr>
<tr>
<td>1980</td>
<td>72.5</td>
<td>66.5</td>
<td>16.3</td>
<td>35.0</td>
<td>1.63</td>
<td>1.86</td>
</tr>
<tr>
<td>1976</td>
<td>70.1</td>
<td>58.0</td>
<td>15.1</td>
<td>34.6</td>
<td>1.52</td>
<td>1.88</td>
</tr>
<tr>
<td>1971</td>
<td>68.8</td>
<td>47.2</td>
<td>15.2</td>
<td>34.6</td>
<td>1.51</td>
<td>2.11</td>
</tr>
<tr>
<td>1968</td>
<td>67.3</td>
<td>44.6</td>
<td>14.1</td>
<td>35.2</td>
<td>1.39</td>
<td>2.01</td>
</tr>
</tbody>
</table>

The model captures the trend of increasing participation since 1968 that is seen in the data. However, it fails to match the magnitude of this increase. It predicts a 20% increase in participation between 1968 and 2000, whereas the CPS data shows a 73% increase over this period. It overpredicts the participation rate in all samples, especially in earlier years. The model also significantly underpredicts hours worked for those that choose to work, again the fit worsens in earlier periods. The distribution of weekly hours shows large spikes at zero and forty hours per week. It will be difficult for any functional form for labor supply to predict this pattern. I outline a method to deal with this issue in the next section. I am trying to explain observed labor supply patterns using variation in prices over time, and I suspect that the lack of variation in the parameters of the wage equation is the principal reason that the model does a poor job of predicting labor supply.

The model captures the pattern of increasing participation over time in the data and matches the observed participation rates quite well for the most recent years. Even though it cannot replicate the magnitude of the increase in participation rates, I feel confident about running some counterfactuals. Intuitively, I am trying to “move” a woman across periods changes to see how her labor supply would change. Since all women are assumed to have
identical preferences, I first impose the wage parameters estimated for the 2000 sample in Table 3 on the 1968 sample. This takes each woman in the 1968 sample, holds all her individual characteristics such as age, education, marital status, number of children and all taxes constant and replaces the parameters of her wage function with those estimated for women in the 2000 sample. Since the model uses changes in the structure of wages over time to explain the increase in participation rates, I expect that participation would have been higher in 1968 if those women faced the 2000 wage parameters. This turns out to be true, with the model predicting a participation rate of 74.0% in 1968 using 2000 wage parameters compared to 67.3% using the actual 1968 wage parameters. This implies that if women in 1968 faced the wage structure estimated for 2000, their participation rate would have been 11% higher.

I also impose the wage parameters from 1968 from Table 3 on the 2000 sample, expecting this to lower the participation rate. If the sample of women from 2000 faced the 1968 wage structure, 73.9% of the sample would have participated instead of the 80.5% predicted under the 2000 wage parameters. This corresponds to a 9% decrease in labor supply resulting from the imposition of the wage structure of 1968.

7 Fixed Costs of Employment

I intend to extend the model to account for fixed costs of employment, which I believe are also an important factor in explaining differences in labor supply behavior. These costs could represent commuting time or items such as special clothing, childcare or transportation costs that must be paid no matter how many hours the individual works. Fixed costs were first introduced into models of labor supply by Hausman (1980) and Cogan (1981), and are often used to help labor supply models fit the data on both the extensive and intensive margins of labor supply. The distribution of weekly hours of work is clustered around 0 and 40 hours of work, a feature that standard utility functions have difficulty replicating. The presence of a fixed cost helps explain why few women work less than “full time” each week, but complicates the analysis by rendering the budget constraint non-convex. The optimal hours choice conditional on participation, a local optimum, may not be a global optimum for utility maximization. Utility comparisons must be used to solve for each workers optimal labor supply. The woman will choose to work if the utility from the optimal hours choice exceeds that from non-participation. Declining fixed costs over time may be another potential
These fixed costs will alter the budget constraint facing every working woman, since I assume that they reduce non-labor income if the woman participates. The slope of the non-linear portion of the budget constraint does not change, since taxes are determined completely by marital status, own and spouses gross earnings and number of children. This implies that the household’s actual tax burden is unchanged as a result of this fixed cost, so the net result is a parallel shift downwards in the budget constraint for all working women, while non-labor income remains $Y$ for all non-workers. Hence, the individual compares utility at non-labor income $Y = Y_i - T^0_i$ (where $T^0_i$ is the household tax burden when she does not work) and wage $w(0) = (1 - \tau^0_i)W$ (where $\tau^0_i$ is the her marginal tax rate when she does not work) with utility at non-labor income $y(h)$ and wage $w(h)$, where $h$ is the optimal choice of hours conditional on participation. This is illustrated in Figure 3.

8 Conclusions

This paper has analyzed the role of prices in explaining the growth in female labor force participation rates over the last thirty five years in the United States. The after-tax market wage rate is taken as a summary statistic for the relative price of leisure. According to the theory, women decide whether or not to participate by comparing the shadow price of their time at zero hours of work (the reservation wage) with their after-tax market wage. If they choose to work, hours then adjust so that demand and supply prices are equal in equilibrium. The model is estimated under the assumption that all women have the same preferences, so
that differences in participation are driven by differences in personal characteristics and the budget constraint. Hence, one set of preference parameters is estimated for the entire period, while the parameters of the budget constraint are allowed to vary over time.

The estimates of the preference parameters all have the expected sign and are significantly different from zero at the 1% level. However, there is not enough variation in the parameters of the wage equation over time to replicate the magnitude of the increase in participation since 1968. The model does predict an increase in participation over this period, but it predicts a 20% increase in participation whereas the data shows a 73% increase over this period.

I would also like to address the issue of cross-country variation in female labor force participation rates. The principal question would still be whether observed labor supply patterns can be interpreted as the same woman responding to different relative prices, but the relative prices would vary across countries rather than over time within the US. Once I have obtained parameter estimates that match the observed patterns in the US data, these preferences parameters could then be combined with data from other countries to see if the predictions from the model match the observed outcomes in the data. With these preference parameters in hand, I will be able to “move” a woman between countries to see if her labor supply behavior would change when facing the wage and tax structure of another country. Other counterfactuals could include investigating how much wages would have to change in countries with lower participation rates in order to “converge” to participation rates observed in the US. From Figure 1, it appears as though participation rates in countries such as Ireland, Spain and Greece are still converging towards US levels.

In conclusion, I believe that changes in relative prices over time have some role to play in explaining the significant increase in female labor force participation since 1968. However, the current model does not capture the magnitude of this increase and also has difficulties matching the observed distribution of hours. Future work will extend this model to include fixed costs of employment and once suitable parameter estimates have been estimated for the US, I will use these estimates to analyze whether cross-country variation in participation can also be explained by differences in relative prices.
References


Appendix A - Variable Definitions

The variables used in the estimation are described below. The definition of certain variables has changed over time. I have attempted to be as uniform as possible.

1. Age. In each sample, this is the individual’s age at the time of the interview.
2. Education. Years of education is used in the estimation, which is collected directly in the CPS before 1992. For years after 1992, only highest grade completed is recorded. This information is combined with an assumption that individuals begin schooling at age 5 to estimate years of education.
3. Number of Children. I am currently using number of own children under 18 in the family. The CPS also collects information on number of children under the age of 6, but only from 1976 onwards. For consistency, children under 18 are used.
4. Marital Status. This is explicitly recorded in all datasets, and a dummy variable is set equal to one if the individual is married with spouse present.
5. Non-labor Income. In this paper, non-labor income is defined as husband’s gross earnings, so that only married women have positive non-labor income. Couples can be easily matched in all waves of the CPS.
6. Household Tax Burden. TAXSIM assumes all married couples file jointly, and reports the tax burden facing the entire household. It calculates both state and federal taxes after 1980, but for consistency only federal taxes are used in the estimation.
7. Marginal Tax Rate. This is computed for each woman using TAXSIM. I compute both the marginal rate given observed labor supply and the marginal rate that she would face if she did not work. This is easily calculated by leaving all other determinants of taxes unchanged and replacing her hours with 0. This marginal rate at zero hours is used to predict which women will work, while the marginal rate at observed labor supply is used to predict how many hours a woman will work.
8. Hours. In the CPS, usual hours worked each week last year is used, which is reported by everyone in the sample post-1976. However, pre-1976, data on hours corresponds to hours worked in the week prior to the interview. This is likely to be a more volatile measure of hours.
9. Wage. In all waves of the CPS, annual income from wage and salary in the previous year is divided by 52 to obtain weekly income from wage and salary, which is then divided by usual weekly hours (or hours last week before 1976) to obtain an average hourly wage. This wage is top-coded at $100 per hour, but this only affects a negligible proportion of each sample.
10. Labor Force Participation (LFP). Women are "participants" (LFP=1) in the CPS if usual hours worked last year is positive post-1976, and if she worked positive hours in the week prior to the survey.

Appendix B - Descriptive Statistics for all Waves of the CPS

Appendix C - Likelihood Estimation

Before deriving the likelihood, I assume that \( \epsilon_i \sim N(0, \sigma^2_\epsilon) \) and \( \eta_i \sim N(0, \sigma^2_\eta) \). The covariance between these two disturbance terms is given by \( \theta \). This implies that \( \epsilon_i - \eta_i \sim N(0, \Psi) \), where \( \Psi = \sigma^2_\epsilon + \sigma^2_\eta - 2\theta \).
The non-worker’s contribution to the likelihood is straightforward to compute. A woman works if \( \epsilon_i - \eta_i < Z_i \). Hence, she will not work if \( \epsilon_i - \eta_i \geq Z_i \) or \( \eta_i - \epsilon_i \leq -Z_i \). So,
\[
\Pr(\eta_i - \epsilon_i \leq -Z_i) \leq \Pr \left( \frac{\eta_i - \epsilon_i}{\sqrt{\Psi}} \leq -\frac{Z_i}{\sqrt{\Psi}} \right) \leq \Phi \left( -\frac{Z_i}{\sqrt{\Psi}} \right)
\]

The worker’s contribution can be derived using the properties of the bivariate normal density. The joint distribution of hours and wages is given by:
\[
n(h_i, \ln w_m^m) = \Pr(h = h_i, \ln w^m = \ln w_m^m) = \Pr \left( \alpha(\eta_i - \epsilon_i) = h_i - \hat{h}_i, \eta_i = \ln w_m^m - \hat{w}_m^m \right)
\]
where the error terms have the following distribution:
\[
\begin{bmatrix}
\alpha(\eta_i - \epsilon_i) \\
\eta_i
\end{bmatrix} = N \left( 0, \begin{bmatrix}
\alpha^2(\sigma^2_\epsilon + \sigma^2_\eta - 2\theta) & a(\sigma^2_\eta - \theta) \\
a(\sigma^2_\eta - \theta) & \sigma^2_\eta
\end{bmatrix} \right)
\]

Hence, the worker’s contribution to the likelihood is can be derived as:
\[
n(h_i, \ln w_m^m) = \frac{1}{2\pi\sigma_1\sigma_2} \exp \left\{ -\frac{1}{2(1 - \rho^2)} \left[ \left( \frac{x_1}{\sigma_1} \right)^2 - 2\rho \left( \frac{x_1}{\sigma_1} \right) \left( \frac{x_2}{\sigma_2} \right) + \left( \frac{x_2}{\sigma_2} \right)^2 \right] \right\}
\]

where \( x_1 = h_i - \hat{h}_i, x_2 = \ln w_m^m - \hat{w}_m^m + \eta_i, \sigma_1 = \alpha \sqrt{\sigma^2_\epsilon + \sigma^2_\eta - 2\theta}, \sigma_2 = \sigma_\eta, \) and
\[
\rho = \frac{\sigma_1^2}{\sigma_1\sigma_2} = \frac{\sigma^2_\epsilon - \theta}{\sigma_\eta \sqrt{\sigma^2_\epsilon + \sigma^2_\eta - 2\theta}}.
\]