The Occupation, Marriage, and Fertility Choices of Women:

A Life-Cycle Model

Bing Ma*
University of Maryland, Baltimore County
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ABSTRACT

An extensive literature in labor economics recognizes that the life-cycle labor force participation of a woman is highly associated with her family choices. There is, however, virtually no study going further to incorporate female occupational choices. This paper attempts to fill this gap in labor supply literature by examining the interrelatedness of occupation, marital status and fertility choices of women over the life cycle. A discrete choice dynamic utility maximization model is constructed to investigate how relevant determinants influence a woman's career and family path and how these decisions interplay with each other. Using longitudinal data on women from the 1979 youth cohort of the National Longitudinal Survey of Youth, I estimate my model through the maximum likelihood estimation method in a dynamic programming fashion which takes into account the uncertainties from random arrivals of job opportunities, unexpected failure of birth control and temporary shocks to family earnings. The estimation results of structural parameters indicate that women's life-cycle patterns of occupation, marriage and contraceptive behaviors vary significantly with their observable characteristics such as age, education, ability, race, and the presence of young children.

Keywords: Human Capital; Occupational Choice; Life Cycle Model; Marriage; Fertility.

JEL Classification: J24, D91, J12, J13.

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*Correspondence to: Economics Department, University of Maryland, Baltimore County, PUP Building 339, 1000 Hilltop Circle, Baltimore, MD 21250. Tel: 410-455-8039, Fax: 410-455-1054. E-mail address: bingma@umbc.edu.

1. Introduction

In recent decades, there has been an increased recognition among labor economists in the study of female labor supply that a woman's labor force participation is highly associated with her family choices like marriage status and fertility decisions. Along with this growing awareness, an expanding literature has been devoted to jointly modeling women's labor supply and family choices. A plethora of studies, for example, examine the interdependence between marital status and labor force participation choices (e.g. McElroy (1985), Johnson and Skinner (1986, 1988), and Van Der Klaauw (1996)), and many others focus on female labor supply and childbearing choices or both marriage and fertility decisions (e.g. Rosenzweig and Wolpin (1980), Hotz and Miller (1988), Blackburn, Bloom and Neumark (1993), Francesconi (2002), Ueda (2007)). Some recent studies further consider schooling as a choice variable along with women's labor force participation, marriage status and fertility decisions (e.g. Gustafsson and Worku (2005), Goldin (2006), Sheran (2007)). The existing studies, however, virtually never explicitly incorporate female occupational choices and model occupational choice, marriage and fertility decisions jointly.

It has been well documented that female occupational choices are strongly correlated with their family choices. According to Budig and England (2001), for example, a woman with children may temporarily interrupt full-time employment or voluntarily trade off higher wages for "mother-friendly" jobs. This is in line with the crux of Becker's (1985) work-effort hypothesis that married women economize on the effort expended on labor market work by seeking less energy-demanding occupations. Several recent studies show that a sizeable minority of professional women prevent the conflicts of dual family and professional roles by remaining single, while many others choose to be childless or postpone childbirth (e.g. Hewlett (2002)).

In addition, demographic trends exhibit a sharply rising share of female professionals in the United States labor force over the past decades. Professional and related occupations are expected to be the most rapidly growing occupational category of women in the U.S.. [1] In 1970, 16.6 percent of the managerial and administrative jobs went to women, and by 2000, women in the closest comparable group (management, business, and financial operations) represented 41.9 percent of the group. [2] The proportion of employed women working in professional and related specialties

[1] See Professional Women: Vital Statistics by Department of Professional Employees (2006).
[2] See the U.S. Census 2000 Special Reports (2005).

increases from 21.9 percent in 1983 to 33.7 percent in 2002,[3] which are expected to increase by more than 21.2 percent over the next ten years.[4]

Therefore, jointly modeling occupation and family choices becomes crucial to a better understanding of the interdependence of the contemporary women's career and family choices. Accordingly, the interdependence of sequential choice decisions has important policy implications in order to reduce work-family conflict for mothers in different occupations. Ignoring the occupational choice inherent in the labor force participation decision could result in inaccurate forecasts of policy changes, mislead our research, and thus fail to capture the inherent dynamic nature of the interaction of female labor supply, marital status, and fertility decisions.

This paper attempts to fill this gap in the labor supply literature by presenting a structural dynamic model that explicitly addresses the interdependence among labor force participation choices, marriage and fertility decisions. In the model, a female maximizes the expected discounted value of her utility each period over her life cycle by simultaneously determining what category of occupation to enter,[5] whether to be married, and whether to use contraception. These decisions depend on her previous career and family choices and have impact on future relevant choices. Correspondingly, individuals derive utility from being married, the presence of children, and the consumption of a composite good as well as the contribution of occupation choices through wage earnings. By setting the sequential choice decisions interdependent, the structural model enables us to examine the joint determination of labor supply, occupation and family choices of women and the dependence of these decisions on the presence of children and other individual characteristics, such as age, race, ability, et cetera. More realistically, the model incorporates various uncertainties, such as those associated with job search opportunities, imperfection of birth controls, and random shocks to current and future wage earnings.

Using longitudinal data on young women from the National Longitudinal Survey of Youth (NLSY), the maximum likelihood estimation along with a convenient dynamic programming method is employed to obtain structural estimates of the model. The estimated structural model appears to be a reasonably good fit to the data. Some findings are noteworthy. Relative to nonprofessional women, for example, the presence of children (especially young children) reduces a female professional's utility flows more dramatically. I also find that the higher AFQT score increases a female's utility

[3] Source: Current Population Survey, U.S. Department of Labor, Bureau of Labor Statistics.
[4] See Professional Women: Vital Statistics by Department of Professional Employees (2006).
[5] Occupation is divided broadly and roughly into three subcategories: professional and managerial, nonprofessional, and housework. Detailed categorization is based on 1977 Standard Occupation Classification System. Choosing the first two means working in the labor force while the latter means staying at home.

flows in dramatic magnitude if she works in a professional occupation. On the contrary, all else equal, the higher AFQT score makes a nonprofessional female's utility flow decreases. Job search cost from other occupations to professionals is about 2.5 times higher than that for the mobility from other occupations to nonprofessional.

The remaining of this paper is organized as follows. Section 2 presents a dynamic structural model for female labor force participation, marital status and fertility pattern decisions. Section 3 describes the dynamic programming method to solve the maximization of women's life-cycle expected discounted value of utility. Section 4 discusses the data. Section 5 deals with the econometric specification and estimation of the model. Section 6 presents the results of estimation with concluding remarks in Section 7.

2. Economic Structure Model

I consider a structural dynamic model in which I focus primarily on a female's decision process for her occupation, marriage, and fertility while ideally assuming that all (potential) husbands always work full time in the labor market.[6] In so doing, I shun away the notoriously complicated multivariate choice problem, and leave the direct contribution of marriage to utility to be characterized solely as some portion of the husband's wage income, share of child-raising expenditure and birth control cost. Utility gains or losses are directly associated with the current combined choice of labor force participation, marital and fertility status as well as the duration of corresponding states. Uncertainties are further taken into account in recognition of the random arrival of job opportunities, temporary shocks to female and male earnings and imperfect control women have over births.

A woman is assumed to maximize the present value of life-cycle utility in each period over a known finite horizon, T, by choosing which occupation to enter, whether to be married, and whether to use contraception, and how much to consume.

Let $p_t = (p_t^M, p_t^L, p_t^H)$ denote the occupation choice variable at time *t*, where $p_t^M = 1$ if a woman chooses to work at managerial and professional specialty occupations and zero otherwise, $p_t^H = 1$ if a woman chooses to do home production

[6] Sheron (2007) presents a similar framework which considers women's education choice along with their career and family decisions.

and zero otherwise,[7] $p_t^L = 1$ if a woman chooses to work at other nonprofessional occupations and zero otherwise.

Let $m_t = 1$ if she chooses to be married at time *t* given that a marriage offer is available and zero otherwise. Let $b_t = 1$ if she doesn't want to get pregnant and uses birth control at time *t* and zero otherwise. Let c_t denote the consumption at time *t*. In this vein, a woman chooses a path $\{(p_t, m_t, b_t) \in I_t;\ c_t \in \Re^+\}$ for $t = 1, 2, ..., T$, where I_t represents the set of choice possibilities for p_t, m_t, and b_t in period *t*. Note that there are three choices of occupation, two for marriage status, two for birth control, and thus totally 12 mutually exclusive choices available each period.

The presence of children has great impact on a woman's utility gain and loss, whilst the ages and number of children have additionally been suggested to be of different effects on her choices. Along with this line, I categorize the children ever born to a woman into two groups in terms of children's number and ages, in order to obtain a clearer picture of the fertility pattern and its effects.[8] Let $n_t = 1$ if a woman gives birth in period *t* and zero otherwise. Let $N_t = \sum_{\tau=1}^{t} n_\tau = N_{t-1} + n_t = N_t^{0,5} + N_t^{6,18}$ denotes the total number of children a woman has up to time *t*,[9] where $N_t^{0,5}$ represents the number of children ever born, as of time *t*, who are under the age of 6, and $N_t^{6,18}$ represents the number of children ever born, as of time *t*, who are between the age of 6 and 18.[10]

Utility also depends on the previous period's work experience and family decisions as well as several other individual characteristics. The disutility of working, for example, may increase over time due to accumulated stress from some particular workload pressure, but meanwhile, it may bring positive effects such as habit formation or complementarity of leisure time in subsequent periods. Observable individual characteristics vector Z_t, such as education, age, race, ability, and religion, capture the heterogeneity of tastes across different individuals. Let $D_t = (L_t^M, L_t^L, L_t^H, M_t)'$ denote the duration vector, where L_t^M is the accumulated labor market experience with managerial or related profession at time *t*, L_t^L accumulated experience in laborer markets at time *t*, L_t^H accumulated experience in housework at time *t*, and M_t refers to

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[7] I treat housework as a classification of occupation.
[8] I only consider children ages 18 years old or younger.
[9] I do not consider the case of multi-birth in a single delivery, which, according to the survey, is very rare, if any.
[10] For simplicity, this paper abstracts from the mortality of children. Also see Wolpin (1984).

the duration of the current marriage at time t. The relation between the duration variables and the current choice variables can be described as

$$\begin{aligned} L_t^M &= L_{t-1}^M + p_t^M \\ L_t^L &= L_{t-1}^L + p_t^L \\ L_t^H &= L_{t-1}^H + p_t^H \\ M_t &= m_t \cdot (M_{t-1} + m_t) \end{aligned} \qquad (1)$$

With the choice variables and state variables described above, the objective of a woman at any time t, $t = 1, 2, ..., T$, is to maximize the expected present value of her future utility stream

$$E\{\sum_{t=1}^{T} \beta^{t-1}[U(p_t, m_t, c_t, b_t; p_{t-1}, m_{t-1}, N_t, D_{t-1}, Z_t)]\} \qquad (2)$$

where β represents the individual's subjective discount factor that is typically presumed to be in the (0,1) interval and E is the expectation operator.

The period utility function is further specified as

$$\begin{aligned} &U(p_t, m_t, c_t, p_{t-1}, m_{t-1}, N_t, b_t, D_{t-1}, Z_t) \\ &\quad = Q(p_t, m_t, p_{t-1}, m_{t-1}, N_t, b_t, D_{t-1}, Z_t) + c_t + \varepsilon(p_t, m_t, b_t) \end{aligned} \qquad (3)$$

where $Q(\cdot)$ is the utility function which describes the utility flow from both current and past choices, family structure and their interdependence, and is assumed to be independent of consumption. $\varepsilon(p_t, m_t, b_t)$ captures preference shock to utility associated with each choice, which are assumed to be independent across time, choices and individuals.[11]

The first term of the utility function is specified as

$$\begin{aligned} &Q(p_t, m_t, p_{t-1}, m_{t-1}, N_t, b_t, D_{t-1}, Z_t) \\ &= b_1 m_t + b_2 p_t^M + b_3 p_t^L + b_4 b_t \\ &\quad + B_1' Z_t m_t + B_2' Z_t p_t^M + B_3' Z_t p_t^L + B_4' Z_t b_t \\ &\quad + A_1' N_t m_t + A_2' N_t p_t^M + A_3' N_t p_t^L + A_4' N_t b_t \\ &\quad + b_5 (1 - m_t) m_{t-1} + b_6 m_t (1 - m_{t-1}) + b_7 p_t^M (1 - p_{t-1}^M) + b_8 p_t^L (1 - p_{t-1}^L) \\ &\quad + b_9 m_t M_{t-1} + b_{10} p_t^M L_{t-1}^M + b_{11} p_t^L L_{t-1}^L \end{aligned} \qquad (4)$$

[11] Also see Rust (1987) and Berkovec and Stern(1991). In this paper, I don't allow for the time dependence in the error structure, which could be incorporated in the future estimation.

where N_t is a vector, i.e. $N_t = (N_t^{0,5}\ N_t^{6,18})'$. Note that b_1 through b_4 captures the direct effects of a woman's choices over marriage, occupation and fertility, B_1 through B_4 reflects the choice-specific effects of individual characteristics like education, age, race, ability, and religion, A_1 through A_4 is the choice-specific effect of having children, b_5 through b_8 is the instant gains (losses) from the current choice deviating from the previous period, while b_9 through b_{11} captures the effects of the previous period's work experience and marital status decision.[12]

Assume that the nature of capital markets are perfectly-imperfect (PICM), i.e. there is no borrowing or savings across time periods, and consumption is separable,[13] the choice decision for consumption of the second component of the period utility function, simply c_t, is subject to the budget constraint,

$$c_t = m_t \cdot \psi\Big(\sum_{k\in\Theta} p_t^k w_t^k + w_t^h - \varphi b_t - (\mu_1 N_t^{0,5} + \mu_2 N_t^{6,18})\Big) + (1-m_t)\cdot\begin{bmatrix} I(N_t^{0,5} + N_t^{6,18} > 0)\cdot WP_t \\ + \Big(\sum_{k\in\Theta} p_t^k w_t^k - \varphi b_t - (\mu_1 N_t^{0,5} + \mu_2 N_t^{6,18})\Big) \end{bmatrix} \quad (5)$$

where $\Theta = \{M,\ L,\ H\}$ denote the set of choices for occupation. ψ represents the proportion of pooled net family income.[14] w_t^M and w_t^L are different wage earnings for a working female corresponding to her occupation choice, w_t^h denotes her husband's wage earnings if she chooses to be married ($m_t = 1$). φ represents the contraception cost. The parameter μ_1 is a multiplier that converts number of children ages under 6 into expenditure in terms of a monetary equivalent consumption value. $I(.)$ is an indicator function equal to unity when the argument is true. WP_t Represents the period t welfare payment a woman receives from the government if she is single but has at least one child under the age of 18.

[12] Another noteworthy aspect is the interdependence between current decision of marriage and occupation, which may also have impact on the utility flow from children, duration variables, and individual characteristics. Including the interactive term would allow us to examine the issue in more depth and may provide further insight into the interdependence of a woman's occupation, marriage, and fertility decision. On the other hand, it may lead to "the curse of dimension" easily due to the computational infeasibility. Hence, I do not include the interaction term for the sake of simplicity of estimation.

[13] See Hotz and Willis (1997).

[14] I arbitrary set ψ =0.5 in the part to obviate the complicated estimation due to data limitation.

The right-hand side of the budget constraint refers to share of a woman's earning and her husband's earning less the portion of expenditures on children and birth control. The first part in the right-hand side of equation (5) describes the case of a married woman while the second part represents the case of a single woman. In addition, a woman's wage earnings are occupation-specific, but as aforementioned, I let her husband's wage to be determined by his individual characteristic *per se,* regardless the female's choice.

The female's own current and future wage earnings are stochastically and will generally depend on the female's previous work decisions. Accordingly, when the female chooses to work, her wage depends on her personal characteristics Z_t, features of her local labor market F_t , and her previous period's work decision, her total work experience, and a random shock to her earnings. Thus

$$\begin{aligned}\ln(w_t^M) = (\delta_1^M)' Z_t + (\delta_2^M)' F_t^M + \delta_3^M p_{t-1}^M + \delta_4^M p_{t-1}^L \\ + \delta_5^M L_{t-1}^M + \delta_6^M L_{t-1}^L + \delta_7^M (L_{t-1}^M)^2 + u_t\end{aligned} \tag{6}$$

$$\begin{aligned}\ln(w_t^L) = (\delta_1^L)' Z_t + (\delta_2^L)' F_t^L + \delta_3^L p_{t-1}^L + \delta_4^L p_{t-1}^M \\ + \delta_5^L L_{t-1}^L + \delta_6^L L_{t-1}^M + \delta_7^L (L_{t-1}^L)^2 + v_t\end{aligned} \tag{7}$$

where F_t^M and F_t^L refer to the professional and nonprofessional local labor market features, respectively. Note that the previous period's work decision, p_{t-1} is included separately other than the duration variable L_{t-1}, allows for a stronger effect of more recent work experience. The shocks to her wage earnings are assumed to be *i.i.d.* over time.

The earnings of each female's (potential) husband in period t are specified as

$$\ln(w_t^h) = (\delta_1^h)' Z_t^h + (\delta_2^h)' F_t^h + \delta_3^h L_{t-1}^h + \delta_4^h (L_{t-1}^h)^2 + v_t^h \tag{8}$$

where Z_t^h is a vector capturing her (potential) husband's personal characteristics, such as education, age, race, religion, etc and the superscript *h* denotes husband. F_t^h a vector capturing her (potential) husband's local labor market features. L_{t-1}^h refers to her husband's work experience. v_t^h is assumed as *i.i.d*. random shocks to her (potential) husband's wage earnings over time.

A woman may give birth as planned, but in some cases childbearing could be unexpected. Thus uncertainty in utility arises when birth control fails. In this regard, although the relation between fertility and birth control is quite straightforward, simply modeling n_t and b_t to be linear would be apparently unrealistic and fail to capture the randomness. Accordingly, I adopt a probit model to specify a woman's life-cycle fertility

$$\begin{aligned}
&\Pr(n_t = 1 \mid X_{t-1}) \\
&\quad = \Phi(\gamma' X_{t-1}) \\
&\quad = \Phi(\gamma_0 + \gamma_1 g_{t-1} + \gamma_2 g_{t-1}^2 + \gamma_3 b_{t-1} + \gamma_4 m_{t-1} + \gamma_5 N_{t-1} \\
&\qquad + \gamma_6' p_{t-1} + \gamma_7 w_{t-1}^h m_{t-1} + \gamma_8' w_{t-1} p_{t-1})
\end{aligned} \tag{9}$$

where $\Phi(\cdot)$ is the standard normal distribution function, g_{t-1} is the age of a woman at time *t*-1, and $X_{t-1} = (1,\ g_{t-1},\ g_{t-1}^2,\ b_{t-1},\ N_{t-1},\ m_{t-1},\ p_{t-1},\ w_{t-1}^h,\ w_t)'$ is the information set at time $t-1$.

Uncertainty also arises with respect to job offers. Realistically, a woman may always be able to choose to stay at home for some period, while job offer opportunities may not be available in that period when she decides to go out for work. In recognition of this, I allow for the possibility that choice set I_t in each period may not include all occupational status options, i.e. the option to get employed in professional or nonprofessional occupations may not materialize in each period when currently unemployed. In addition, I permit the probability of such an event to differ for different individuals, by characterizing the arrival of a job offer opportunity in each period by that arrival rate, $\Upsilon(p_{t-1}, Z_t)$, which depends on the occupational choice in last period, vector of individual characteristics and the unemployment rate of local labor market, Z_t. Let J denote the subset of I_t only related to occupation choice. I have the following cases:

1) if both categories of job offer opportunity exist,

$$J_1 = \left\{ p_t^M \in \{0,1\},\ \ p_t^L \in \{0,1\},\ \ p_t^H \in \{0,1\} \right\}$$

2) if only managerial job offer opportunity exists,

$$J_2 = \left\{ p_t^M \in \{0,1\},\ \ p_t^L = 0,\ \ p_t^H \in \{0,1\} \right\} \tag{10}$$

3) if only laborer job offer opportunity exists,

$$J_3 = \left\{ p_t^M = 0,\ \ p_t^L \in \{0,1\},\ \ p_t^H \in \{0,1\} \right\}$$

4) neither of job offer opportunity exists,

$$J_4 = \left\{ p_t^M = 0,\ \ p_t^L = 0,\ \ p_t^H = 1 \right\}$$

I further assume that if a woman has been in the labor force, then job offer opportunity for the category occupation of her current job will always exist. And also if she works in managerial profession, she will always have the option to choose to work in laborer profession. Thus, for example, the arrival rate given a woman does not work in the previous period, $\Upsilon(p_{t-1}, Z_t)$, is specified as

$$\Pr(J_s \mid p_{t-1}^H = 1) = \Upsilon_s((0,0,1),\ Z_t) = \Phi(\pi_s{}' Z_t) \quad \text{for } s = 1,2,3 \qquad (11)$$

$$\Pr(J_4 \mid p_{t-1}^H = 1) = \Upsilon_4((0,0,1),\ Z_t) = 1 - \sum_{s=1}^{3} \Phi(\pi_s{}' Z_t)$$

The similar concern would be raised about marital search. One may claim that, like job offer opportunity, a single woman may not find a potential husband in some periods although she would like to be married at these episodes. Undoubtedly, incorporating the uncertainty associated with marital search would upgrade the completeness of model setting. The computational cost, however, is also overwhelmingly high. Combining the incomplete choice sets due to marital search with job search, I may have $4 \times 2 = 8$ J 's, and accordingly $8 \times 2 \times 3 = 48$ Υ 's, which thereby substantially increases the number of the parameters to be estimated. Given that, I may be left with no much option but sidestep this randomness.

3. Data Description

This study extracts data from the National Longitudinal Survey of Youth (NLSY). The NLSY started in 1979 with a sample of 12,686 youths ages 14-22 which includes a nationally representative of young people living in the United States in 1979 and a supplementary low-income and minority sample. The survey collects a wealth of longitudinal information as demographic and family background characteristics, labor market experience, educational attainment, occupational aspirations, marital history, child care, pre- and post-natal health behaviors, and religious affiliation. [15] This paper utilizes a subsample of 622 out of 3,077 women aged between 18 and 21 in 1979 (or 21-24 in 1982 and 35 to 38 in 1996) from 1982 through 1996.[16] This age group was

[15] Sample members were interviewed annually from 1979 through 1994, and were interviewed on a biennial basis thereafter.

[16] Three independent probability samples comprise the NLSY79 data. The three samples are: (1) a cross-sectional sample (6,111) designed to be representative of the noninstitutionalized civilian segment of young people living in the United States in 1979 and born 1957 through 1964 (2) a set of supplemental samples (5,295) designed to oversample civilian Hispanic, black, and economically disadvantaged, non-Hispanic, non-black youth born in the same time period (3) a military sample (1,280). 173 were dropped

selected to better incorporate fertility behaviors over women's fertile years. Moreover, we are in a better position to assume that education decisions have been completed by the first observation year.

I choose NLSY79 to take its many advantages that very well suit this analysis. In addition to the timing of marriage, divorce, and birth events, it provides valuable information on the contraception choices of women which was regularly collected annually from 1982 to 1986. After 1986 the questions were asked biennially. [17] I use regression imputation method to impute those years that we can't observe contraceptive usage. The survey also collects detailed information on female's labor market activities and transitions, including current labor force status (i.e., employed, unemployed, out of the labor force), job characteristics such as occupation, class of worker, rate of pay, and hours worked per week for the current or most recent job.

A woman is defined to work in professional, non-professional or home production specialty if her current job or most recent job belongs to professional, non-professional or home production category, respectively, on the basis of job characteristics regarding occupation description.[18] In computing the female's and her (potential) husband's wage earnings, I follow the treatment by Van Der Klaauw (1996), Swann(2005), and Sheran (2007), assuming all labor market work is full-time, and calculate the wage earnings as her/his hourly wage rate multiplies 2000 hours. A woman is defined to be married if she is married before the first of March. [19] A woman is defined to be using birth control in a given year if she states that she is utilizing certain method of contraceptive throughout the year.

Other than these choice variables, I further define binary variable of birth event, n_t, which takes value one if a woman is observed to give birth in a given year before the first of March and zero otherwise, and dummy variables accounting for the personal characteristics of sample members: "White" equals one if she is white and zero otherwise. "Protestant" is a dummy variable to denote whether a women is Protestant, and "Catholic" is a dummy variable for whether she is Catholic. I also include The AFQT score which allegedly measures individual's general mental ability and abilities

due to missing AFQT score or education background; 1529 women in the nationally representative subsample were rejected because they were 17 years of age or younger; 753 respondents were dropped due to missing data.

[17] I run a crude probit model of contraception use based on the information collected in 10 out of 14 years to impute the contraceptive usage in 1987, 1989, 1991, and 1993. In period t, if the predicted probability of contraception usage is larger then .7, I encode it as 1.

[18] Occupational categories are grouped based on the 1977 Standard Occupation Classification System.

[19] The NLSY79 was typically conducted during February and March.

leading to potential success. [20] The original AFQT scores are ranged from 0 to 100. To reduce the computational burden, I rescale "AFQT score" to equal one if she earned a score between 0 and 25, two if the score is between 26 and 50, three if the score is between 51 and 75 and four if the score is between 76 and 100. [21]

Table 1 presents the descriptive statistics for the sample. As mentioned above, sample members are chosen conditioned on their finishing schools. Thus the first observation year for each woman is defined as the year when she first left school, [22] while the last sample year is 1996. Each sample member is observed for 14 years and thus there are totally 8708 person-year observations for all sample members across the sample span. The table shows that white women account for about 90 percent of these 622 females with an average age of 20 in the period they first entered the sample. The initial average education level is about 12.5 years, which indicates the majority of the selected cohort have obtained a high school degree. Averaging over the person-year observations, a representative woman is nearly 29 years old, earning a wage of $10.78 per hour. [23] Of the total 8798 person-year observations, over 57 percent are found having children younger than 18 years old, of which more than 42 percent are under 5 years old, nearly 56 percent are married, about 82 percent are using birth control. In terms of occupation, 25.5 percent are specialized in professional occupation, 61.3 percent in non-professional specialties, and 13.1 percent not working in the labor market.

Table 2 reports the summarizing statistics for three subsamples concerning marital status. 100 out of 622 women in the sample have never been married by the end of 1996, which constitutes 1400 persons-year observations. It indicates that an average never married woman is a white 28 years old, has some college with about 14.4 years of schooling. On average, she has a child ages 5 or younger with a 0.087 probability, much smaller than her married counterpart, 0.489. Conditional on marriage, the ever divorce sample exhibits a little lower probability of presence of young children at 0.399. Compared with 24.7 percent are specialized in professional occupation for married sample, only 19.8 percent are professional women in ever divorced group, and in sharp contrast with 29.6 percent in the never married cohort. As expected, married cohort use birth control at the about 78.2 percent of the time, a little lower than 81.6 percent for ever divorced and 91.5 percent for never married women.

[20] The AFQT score is the score earned on the Armed Forces Qualification Test in 1981. The test contains 100 questions equally distributed among the following four areas: vocabulary or verbal concepts; arithmetic; spatial relations; and mechanical ability.
[21] The same treatment is taken by Sheran (2007).
[22] In this paper, I do not consider the returning school after some working spell cases.
[23] All wages are reported in 1982 dollars.

Tables 3-6 describe the distribution between occupation, marital status, fertility and education. All evidence strongly indicates the significant association between career choices and family decisions as well as personal characteristics. Roughly speaking, there are slightly more never-married women working as professionals while much less are out of labor market. Professional women tend to be childless or to delay childbearing relative to other occupational counterparts while few non-working females choose to be childless. As far as education and ability are concerned, as expected, professional women's typically have more education and receive higher AFQT scores than the other women but no significant difference is documented between non-professional and non-working.

4. Dynamic Programming Optimization

The discrete choice life-cycle maximization problem can be tackled with dynamic programming. The major benefit of expressing the infinite (or finite) horizon optimization problem by using Bellman equation is that a multi-dimensional problem can be reduced to a sequence of two period problems, and solved recursively. An even nicer feature of dynamic programming is that it allows for the reward function (period utility function) to be stochastic without adding much computational cost.

As of the model described above, when incorporating the budget constraint (5) and the life-cycle fertility pattern (9) into the utility function (2), the resulting dynamic utility maximization problem turns to be

$$\max_{\{(p_t,m_t,b_t),t=1,..,T\}} E\sum_{t=1}^{T}\beta^{t-1}\left[\mathbb{U}\left(p_t,m_t,b_t,\mathbb{Z}_t,w_t\right)\right] \qquad (12)$$

where $\mathbb{Z}_t$ is a vector containing all the lagged variables including p_{t-1}, m_{t-1}, b_{t-1}, D_{t-1}, and N_{t-1}, and the current observable individual characteristics variables Z_t and the welfare payment WP_t. w_t is the wage earnings vector including the female's occupation-specific wage earnings w_t^M and w_t^L, and her husband's wage earnings w_t^h. The expectation is taken into account the randomness associated with the woman's future choices, fertility pattern, wage earnings, and the choice-specific stochastic utility component $\varepsilon(p_t,m_t,b_t)$.

As mentioned above, there are totally 12 possibilities or "alternatives" available to a woman each period with respect to the choice variables (p_t,m_t,b_t). Accordingly, I have 12 possible choice-specific period utility functions each period which are stochastic due to the choice-specific error term. Let $d_k(t)$ denote the decision variable such that $d_k(t)=1$ if she chooses alternative k and $d_k(t)=0$ otherwise, and $k \in I$. Given the woman's choice, $d_k(t)=1$, I can define the stochastic reward function as

$$R_{kt} = u_k(\mathfrak{Z}_t) + \varepsilon_{kt} = \mathfrak{Z}_t^{'}\omega_k + \varepsilon_{kt}, \quad \mathrm{k} \in I \tag{13}$$

where $u_i(\cdot)$ denote the deterministic part of the period utility function given the individual chooses alternative k, $\mathfrak{Z}_t$ denote the vector of variables including the lagged variables, the observable personal characteristics variables for a woman and her husband, the ones used in a probit model of life-cycle fertility and the wage earnings equations. ω_k is the vector of coefficients of the corresponding to these variables. ε_{kt}, $t=1,...,T$ are the choice-specific composite random components associated with the female's utility function, wage earnings, and fertility, which are assumed to be independently distributed over time and individuals.

Denote the relevant information set as $S(t)$, which contains the current realizations of the error terms ε_{kt}, the vector of current and lagged variables, $\mathfrak{Z}_t$, and the values of ω_k's, the dynamic program can expressed as

$$V_t(S(t)) = \max_{k \in I_t}\left\{R_{kt}(S(t)) + \beta E\left[V_{t+1}(S(t+1)) \mid d_k(t)=1,\ S(t)\right]\right\} \tag{14}$$

for $t=1,...,T-1$, $k \in I$

$$V_T(S(T)) = \max_{k \in I_T}\left\{R_{kT}(S(T)\right\} \tag{15}$$

for period T.

Starting from the last period value function V_T in (15) and given a distribution assumption for the ε_{kt}'s, I can solve the model backwards to find all the optimal value functions $V_t(S(t))$ for $t=1,...,T-1$. Note that the backwards recursion in solving the dynamic programming problem is straightforward though, it still involves the evaluation of the conditional expectations $E\left[V_{t+1}(S(t+1)) \mid d_k(t)=1,\ S(t)\right]$ for each choice k and period t, which is not a trivial task. In addition, the multivariate integration necessary to calculate the conditional expectation generally does not have a closed form solution. However, according to Dubin and McFadden (1984), the extreme value distribution assumption of ε_{kt} would allow us to obviates the necessity of numerically computing multivariate integrals.

5. Estimation

As discussed previously, to make analytically solving the dynamic optimization problem feasible and to facilitate our estimation of parameters, I need to restrict the composite error terms, ε_{kt}'s, to follow certain preferable distribution. A popular choice is to assume they are independently and identically extreme value distributed with density function as:[24]

$$F(\varepsilon_{kt}) = \exp\left\{-\exp\left\{-\varepsilon_{kt}/\sigma\right\}\right\},\ k \in I \qquad (16)$$

where σ is scale factor such that the variance of ε_{kt} equals $\sigma^2\pi^2/6$.

The benefit of *i.i.d.* extreme value distribution assumption is that it greatly simplified the expectation of the optimal value function, the second term in equation (14),

$$\begin{aligned} E\left[V_{t+1}(S(t+1)) \mid d_k(t)=1\right] &= E\left[\max_{k\in I}\ V_{kt}(S(t+1)) \mid d_k(t)=1\right] \\ &= \sigma\gamma + \sigma \cdot ln\left(\sum_{k\in I} \exp\left\{u_k(\Im_{t+1}) + \beta E\left[V_{t+2} \mid\ d_k(t+1)=1\right]/\sigma\right\}\right) \end{aligned} \qquad (17)$$

where $\gamma = 0.577216$ is the Euler's constant, and $u_k(\Im_{t+1}) = R_{kt+1} - \varepsilon_{kt+1} = \Im'_{t+1}\omega_{k+1}$ as defined above,[25] and also a close form for the conditional probabilities for the choice of alternative k, which is specifically a well-known multinomial logit formula.

$$\Pr(d_k(t)=1 \mid \Im_t)$$

$$= \frac{\exp\left[u_k(\Im_t) + \beta E\left[V_{t+1}(S(t+1)) \mid\ d_k(t)=1,\ S(t)\right]\right]}{\sum_{j\in I}\exp\left[u_j(\Im_t) + \beta E\left[V_{t+1}(S(t+1)) \mid\ d_j(t)=1,\ S(t)\right]\right]} \qquad (18)$$

What remains is to incorporate the restriction from the availability of job choice set. As I have discussed before, in some periods a woman prefers working, but she has to stay at home due to the poor job marketing. And thus I need to update (16) and (18) with respect to the incompletion of the choice availability. According to the law of total probability, the probability that alternative k is chosen in period t can be expressed as

[24] See, for example, Dubin and McFadden (1984), Rust (1987), Berkovec and Stern (1991), and Van Der Klaauw (1996).

[25] In general, the multivariate integration necessary to calculate the left hand side term in equation (17) can only be solved numerically without a closed form solution.

$$\Pr(d_k(t)=1\mid \mathfrak{Z}_t)=\Upsilon_1\cdot\Pr(d_k(t)=1\mid \mathfrak{Z}_t,J_1)+\Upsilon_2\cdot\Pr(d_k(t)=1\mid \mathfrak{Z}_t,J_2)$$
$$+\Upsilon_3\cdot\Pr(d_k(t)=1\mid \mathfrak{Z}_t,J_3)+\Upsilon_4\cdot\Pr(d_k(t)=1\mid \mathfrak{Z}_t,J_4) \qquad (19)$$

where $\Upsilon_s \equiv \Pr(J_s \mid p_{t-1}^H=1)=\Phi(\pi_s{}'Z_t)$ for s=1,2,3

$$\Upsilon_4 \equiv \Pr(J_4 \mid p_{t-1}^H=1)=1-\sum_{s=1}^{3}\Phi(\pi_s{}'Z_t)$$

Accordingly,

$$\Pr(d_k(t)=1\mid \mathfrak{Z}_t,J_s)=\begin{cases}\dfrac{\exp\left[u_k(\mathfrak{Z}_t)+\beta E\left[V_{t+1}\mid d_k(t)=1\right]\right]}{\sum_{j\in J_s}\exp\left[u_j(\mathfrak{Z}_t)+\beta E\left[V_{t+1}\mid d_j(t)=1)\right]\right]} & \text{if } k\in J_s\\ \text{zero otherwise}\end{cases} \qquad (20)$$

for $s=1,2,3,4$. I suppressed state variables to save space.

and,

$$E\left[V_t(S(t))\right]=E\left[\max_{k\in I} V_{kt}(S(t))\right]$$
$$=\sigma\gamma+\sigma\cdot\sum_{s=1}^{4}\left\{\Upsilon_s\cdot ln\sum_{j\in J_s}\exp\left\{\left[u_j(\mathfrak{Z}_t)+\beta E\left[V_{t+1}\mid d_j(t)=1)\right]\right]/\sigma\right\}\right\}$$

. (21)

Provided that parameters and the function forms of $u_k(\mathfrak{Z}_t)$ and arrival rates of job offer opportunities are known, I can easily compute the values of the expectation of the value functions, { $E(V_1),E(V_2),...,E(V_T)$ }, and hence substitute into (20) to obtain the restricted conditional choice probabilities, $\Pr(d_k(t)=1\mid \mathfrak{Z}_t,J_s)$ for $t=1,...,T$, $k=1,...,4$, recursively, and finally to compute the unrestricted conditional choice probabilities in (19), $\Pr(d_k(t)=1\mid \mathfrak{Z}_t)$ for $t=1,...,T$.

Given observed data on an individual's choices and state variables and the solution to the dynamic programming problem, we are now in position to state exactly how the structural parameters of model can be estimated. To alleviate computation burden of dynamic programming problem, I estimate the earning equation and the birth probit model outside of the structure model, and then δ in earning equations (6)-(8) and γ in birth probability function in (9) are treated as given in the following estimation of structure model.[26] By assumption, all workers are assumed to work full time, therefore I multiply hourly wage with 2,000 hours as an individual's wage earnings.[27] I use Heckman's two-stage model to correct selection bias caused by using data only on female workers (Heckman 1974).The NLSY doesn't provide much information on husband's characteristics. Therefore, each (potential) husband's observable characteristics are assumed the same as his wife. This approach has been used by Van Der Klaauw (1996). The birth probability model is estimated by controlling age, lagged birth control, lagged marital status, lagged occupational choices, and own wage as well as her (potential) husband's wage earnings. Estimates of parameters in birth function are used to predict the probability of giving birth in the structure model.

Let θ denotes the parameters to be estimated, which includes ω_k in equation (13) and π's associated with the arrival rates in (19). The parameters are estimated by maximizing the likelihood function for the sample data. Given a panel of T ($T=14$) periods' time series observations on N=622 individuals, I can construct the sample likelihood function based the choice probabilities:

$$\begin{aligned}\mathfrak{L}(\theta) &= \Pr(d_1^1(1),\ldots,d_1^1(T),d_1^2(1)\ldots,d_1^N(T),d_2^1\ldots d_K^N(T)\mid\theta)\\ &=\prod_{i=1}^{N}\prod_{k=1}^{K}\Pr(d_k^i(T)\mid d_k^i(T-1),\ldots,d_k^i(2),d_k^i(1);\theta)\cdot\ldots\cdot\Pr(d_k^i(2)\mid d_k^i(1);\theta)\cdot\Pr(d_k^i(1)\mid\theta)\\ &=\prod_{i=1}^{N}\prod_{k=1}^{K}\prod_{t=1}^{T}\Pr(d_k^i(t)\mid \mathfrak{Z}_t;\theta)\end{aligned} \quad (22)$$

The likelihood function taking the simple form of the product of the choice probabilities across individuals and time is attributed to the *i.i.d.* extreme value distribution of the composite error terms.

The likelihood function in equation (22) is maximized numerically based on Newton-Raphson algorithm. The kernel of the iteration equation of the algorithm is specified as

$$\theta^{(m+1)} = \theta^{(m)} + \left[H(\theta^{(m)})\right]^{-1}\cdot g(\theta^{(m)}) \quad (23)$$

where $g(\cdot)$ and $H(\cdot)$ are the gradient vector of the log likelihood function and the Hessian matrix of second derivatives of the log likelihood function:

[26] Taking into account of the possible selection bias of the women sample due to using data only on workers, I use Heckman's two stage method (1974) in the estimation of women's wage earning equation. Men's wage earning equation are estimated directly through OLS.
[27] See also Swann(2005) and Van Der Klaauw (1996).

$$g(\theta_0) = \left. \frac{\partial \ \log \mathfrak{L}(\theta)}{\partial \theta} \right|_{\theta=\theta_0}$$

$$H(\theta_0) = \left. \frac{\partial^2 \log \mathfrak{L}(\theta)}{\partial \theta \ \theta^{'}} \right|_{\theta=\theta_0}$$

The supscript *m* denotes the *m*th iteration. The estimation begins with an initial guess of $\theta^{(0)}$. Based on this initial value, the likelihood function and the derivatives $g(\theta^{(0)})$ and $H(\theta^{(0)})$ are computed. $g(\theta^{(0)})$ and $H(\theta^{(0)})$ are used to update θ by (23). Continue the iteration for $m = 1, 2, \ldots$ until for some m^* such that $\left\| \theta^{(m^*)} - \theta^{(m^*-1)} \right\|$ is less than certain preset tolerance, say 10^{-8}.

It is important to note, from a methodological point of view, that the choice of error structure is crucial for the way that a discrete choice dynamic model is solved and estimated. Adopting an error structure independently distributed over time and individuals, as many researchers like Rust (1987), Berkovec and Stern (1991), and van der Klaauw (1996), implicitly assumes that the observed career choices and family decisions of women are captured by the variation in their observable characteristics. And this is to assume that the unobserved heterogeneity is irrelevant and that the error term is serially uncorrelated. Nevertheless, there is evidence that certain unmeasured variables may be important in characterizing the exhibited serial persistence women's labor supply behaviors and marital and fertility patterns other than state dependence, and that the error term is also likely to be autocorrelated.

It has been well-known that the high degree of serial persistence in female's working behavior in discrete panel datasets can be possibly attributed to state dependence, unobserved permanent heterogeneity, and autocorrelation in the error term. Heckman and Willis (1977) and Heckman (1981) distinguish these two sources of time persistence as "true state dependence" and "spurious state dependence" respectively. There is true state dependence if previous participation choices affect current labor supply decisions. Interpretations of state dependence include human capital accumulation (e.g. Heckman 1981), intertemporally nonseparable preferences for leisure (e.g. Hotz, Kydland, and Sedlacek 1988), search costs of finding a new job (e.g. Eckstein and Wolpin 1990), and fixed costs of work such as child care needs, transportation, relocation of housework, resolution of scheduling conflicts which might differ by the previous employment state (e.g. Nakamura and Nakamura 1994, Prowse 2005). For example, a woman leaving the labor market to care for a new born may suffer from depreciation in the stock of human capital (work experience) during the period she is not active in the work force, and thus may be likely to remain out of the labor market the following year. Potential employers may also believe that a female who has been unemployed is not as productive as an identical applicant who has not experienced these events, which increases the search costs for nonparticipants.

In contrast, serial persistence due to spurious state dependence is attributed to permanent unobserved heterogeneity in which the unobserved individual component determines current participation irrespective of past working status. In terms of the association between female labor supply and children, for example, a woman with a higher "taste" for children and with lower unobservable abilities and skills on the labor market is more likely to be observed to have higher fertility and low labor force participation while a female with strong preference for a career will be rarely recorded as being inactive in the labor market.

Correctly distinguishing between state dependence and unobserved heterogeneity is not only theoretically meaningful, but also has important implications for policy makers choosing different labor market and social policies. For example, if there is substantial permanent unobserved heterogeneity, policies which is aiming to encourage non-employed individuals into full-time jobs must have effect on fostering individual's tastes and motivation for work while if there is substantial state dependence, policies which can help accumulate human capital or lower barriers to labor market entry (e.g. costs of job search, child care needs, etc.) is likely to increase the number of individuals who are in full-time employment. On the other hand, a same labor market or social policy may have different effects in these two scenarios. In case of spurious state dependence, a temporary policy intervention encouraging labor force participation may only have a single period effect on employment behavior while if true state dependence is present, such a policy intervention will have a lasting effect on employment behavior. In this regard, noted by Heckman (1981) that, if heterogeneity is present in the true model and one ignores it, estimating a model that only allows for state dependence, on will tend to overestimate the degree of state dependence. Equally true, but less often noted, is the fact that if state dependence is present in the true model and one ignores it , estimating a model with only heterogeneity, then the heterogeneity in the population will tend to be exaggerated. In the same line, Carro (2003) point out, permanent unobserved heterogeneity may bias estimates and lead to misleading conclusions about the effect of a variable if we do not control for it, and "in dynamic model, the state dependence coefficients are seriously biased getting significative coefficients even when there is no state dependence and persistence is only due to permanent heterogeneity".

As a consequence, using models with more general specifications allowing for unobserved heterogeneity and state dependence as well as autocorrelation is an important issue in econometrics. Several recent studies of female labor supply have followed this approach. Using maximum simulated likelihood (MSL), Hyslop (1999) estimates both dynamic panel probit and linear probability models of female labor supply that included a rich pattern of unobserved heterogeneity and true state dependence, as well as autoregressive errors. Based on U.S. panel data PSID, Hyslop finds that participation decisions are characterized by significant state dependence, unobserved heterogeneity, and negative serial correlation in the error component. Adopting the same model as Hyslop (1999), Islam (2005) and Okamura and Islam (2006) examine the effects of state dependence, unobserved heterogeneity, and serially correlated transitory error in the participation behavior of married women in Sweden and Japan, respectively. Quite different from Hyslop (1999), they find the effect of state dependence is negligible, but the serially correlated transitory error has significantly positive effect on female's participation behavior. In the same line, Chib and Jeliazkov (2004) apply a semiparametric hierarchical Bayes analysis to the setting of Hyslop (1999). They show that their results strengthen Hyslop's (1999) finding that participation is characterized by significant state dependence, and also find support for the presence of heterogeneity in the effect of children on the mother's labor supply.

One rather surprising finding by Hyslop (1999) is that when dynamic factors in female labor supply are excluded, fertility is not exogenous while in dynamic specification with serially correlated errors he finds no evidence against the exogeneity of fertility hypothesis. This, apparently, deviates from the conventional wisdom. One plausible explanation, or probably one drawback of Hyslop's approach, is that he excludes the possibility of interaction between the participation history and fertility. It is generally accepted that the presence of children, and especially young children, decreases the labor supply of the mother (e.g. Mroz 1987), and that women plan the number and timing of their children according to labor market factors (e.g. Waite and Stolzenberg 1976). Hence, it is strongly suggested that fertility decision should be examined in a more realistic manner, in which fertility and female labor force participation decisions are jointly taken into account (e.g. Moffitt 1984, Hotz and Miller 1988, Del Boca 2002). In addition, Carrasco (1998) presents a switching model which accounts for selectivity bias as well as for other form of time invariant unobserved heterogeneity. His results indicate that assuming the exogeneity of fertility induces a downward bias in absolute value in the estimated negative effect of fertility on participation. Recently, Keane and Sauer (2006) extend Hyslop's framework to allow classification error in employment status. They find that a fairly small amount of classification error is enough to overturn Hyslop's conclusions, leading to overwhelming rejection of the hypothesis of exogenous fertility. One another issue regarding Hyslop's model is noteworthy, that he considers only married women. Since the sorting of individuals into marriage is nonrandom and the personal characteristics that affect marriage formation are likely to be related to characteristics that affect labor supply behavior. On the other hand, it is well known that marriage and fertility decisions are highly interdependent. Conditioning on the completed choice of marriage may induce a sample selection bias and, to some extent, imposes predeterminedness on fertility.

After incorporating unobserved heterogeneity to the framework of the present paper, the estimated effects of state dependence, or duration effects, in women's choices for occupation, marriage, fertility, and birth control would be expected to be smaller but statistically significant, given the evidence documented by the previous studies on U.S. panel data that spurious state dependence due to unobserved heterogeneity is significant and robust. The effect of relaxing the assumption that choice-specific error terms are independent over time and individual to allow serially correlated error terms may be ambiguous. First, the previous studies have found disaccording results across different data sets, like Hyslop (1999), Islam (2005), Croda and Kyriazidou (2005), and Michaud and Tatsiramos(2005)28. Second, virtually no studies have attempted to examine the multivariate error terms associated with women's choices for occupation, marriage, fertility and contraception use. It is practically hard to reasonably predict the compound effects from these error terms. Third, past empirical evidence on discrete-choice models with random effect has indicated misspecification of serial correlation error structure has fairly minor effects on the estimates of the coefficients for exogenous variables (e.g. Keane 1997).

6. Empirical Results

6.1 Parameter Estimates

The dynamic model is estimated using maximum likelihood estimation with the discount factor $\beta = 0.9$.[29] Table 7 presents parameter estimates and standard errors of the female and male wage earnings equations. It shows that education and ability have positive effects on wage earnings for both women and men, regardless of which job category a woman holds.

After controlling the working experience, I find that age has a mixed effect on women's wage earnings in that professional women significantly benefit from aging, while their nonprofessional counterparts get slightly lower wage earnings as they get

[28] The latter two reject the hypothesis of AR(1) in dynamic labor supply model using German data.

[29] The choice of the discount factor is somewhat a convention along with the literature while different values may be tried.

older. One possible justification is that professional jobs call for mental maturity and technical sophistication, which are developed with age. Although age and thus experience are undoubtedly important, most nonprofessional jobs lay relatively more weight on youthfulness. Another explanation regarding the negative effect on wage earnings for the nonprofessional female could be that they have higher rate of depreciation of human capital over time than their professional counterparts since leaving school.

The effects of last period experience are of most interest. If maintaining the previous category of job, the previous period's job decision and working experience have considerably positive effect on the current wage earnings while job switching has different effects for different groups of women. A current professional woman may suffer from her previous nonprofessional working experience while a current nonprofessional female could take advantage of her former professional working experience, especially for those who just shifted from the professional positions. All working people are affected by their ethnic status and their respective job market features. In particular, white men and white professional women earns substantially more than their nonwhite counterparts, while nonprofessional female may only slightly get higher wage earnings than the nonprofessional nonwhite counterparts. Although both consistently affecting workers' earnings, the average wage level is a more important factor than the unemployment rate as of the market features.

Table 8 reports the estimates of the probit model which accounts for the probability of a woman giving birth at time t given the information observed at time $t-1$, which includes her age, marital status, whether she uses any contraceptive methods, the number of children she has had, last period's working decision, her husband's wage earnings if married, and her own wage earnings if she is working. The predicted probit model shows that birth control has a significantly negative effect on the probability of future childbearing, while maintaining wedlock produces an opposite effect with a similar magnitude.

Age, as expected, is negatively associated with the birth probability in a modest manner. The result regarding aging, however, is somewhat blurred since according to Hotz and Miller (1988), a woman's birth probability may be peaked around the age of 25 and then followed by a rapid fall. This suggests that classifying the sample data into different cohorts in terms of women's age may allow us to examine the aging effect in more depth. In addition, a working female may lower the probability of her next period's childbearing, regardless of what kind of job she is taking. However, professional women exhibits much lower fertility size than their nonprofessional counterparts. As of income, a rise in a woman's own wage earnings and her spouse's wage earnings will surely increase the pecuniary affordability of additional child for the family. As a result, the probability of next period birth is substantially positively correlated with the couple's wage earnings, in which there are no significantly different income effects between professional women and nonprofessional women. Intriguingly, the number of children a woman ever born seems to have no significant effect on her next birth after controlling all other covariates.

Table 9 presents the estimates of the structural parameters. As shown in the table, a married woman enjoys higher utility flows when aging, which can be attributed to the impact of maturation. In terms of ethnic status, nonwhite women obtain lower utility flows from marriage than whites. One of the possible reasons may be nonwhite women enjoy relatively lower level of his spouse's wage earnings since the latter has been reported to have significant lower wage earnings level than white men.

The presence of children, especially young children, increases the utility gains from marriage. This is consistent with Becker's (1973) approach to marriage that views children born within marriage as marriage-specific capital. The divorce cost is \$2,522 in thousands of 1982 dollars, which could be interpreted as the net benefit of getting divorced for females this period. Correspondingly, the negative estimates associated with marriage, \$1,483, is the fixed utility cost of getting married, which could be viewed as representing the economic cost she may share for the marriage ceremony.

Table 9 also indicates that both professional and nonprofessional women benefit significantly from working experience in their respective occupations. Professional women enjoyed from longer working experience with a higher magnitude than her nonprofessional counterparts. In the meantime, age has different impacts on working females. A professional worker derives substantial positive utility flows in age, while their nonprofessional counterparts are induced a considerably negative utility flows when they are getting older. In this vein, it is consistent with what has been discussed above about the effect of age on wage earnings with respect to different category jobs. Nonwhite females, as the table shown, enjoy lower utility flows from labor market work regardless of the category of jobs, while the white professionals get markedly more utility flows than the white nonprofessionals.

Another interesting finding is that the higher AFQT score increases a female's utility flows in a dramatic magnitude if she works in a professional occupation. On the contrary, all else equal, the higher AFQT score makes a nonprofessional female's utility flow decrease, which may be due to her unsatisfactory work fulfillment conditional on her higher ability. As expected, estimates of education reveal that education increase a working woman's utility flows, especially for professionals.

Related to the fertility status, table 9 shows that the presence of children significantly decreases the utility gains from labor market work. Not surprisingly, this decrease is much greater for children under the age of six for whom caring is more time-intensive compared to children age 6 and older. It is noteworthy that the estimates further indicate that on average professional women suffer more than nonprofessionals in the presence of children. This could be mainly because those children, especially the very young, are negatively related to female labor supply. For example, Lundberg and Rose (2000) show that a first child reduces female wages by 5 percent and hours by 45 percent. In general, the opportunity cost of spending more time at home to take care of children for professional women is higher than nonprofessionals. As a result, the children (particularly young children) decrease professional women's utility at a higher magnitude than the nonprofessional females.

Job search cost from other occupations to professionals is about $3,453 on average, which is much higher than $1,349 for the mobility from other occupations to nonprofessional. This infers that the interruptions of working continuation will blemish a professional woman more than a nonprofessional, and is more costly for professional woman. Therefore, we could expect and rationalize the fact that the fertility pattern of a professional woman is quite different from the other two groups. For example, occupational upward mobility is associated with higher probability of being unmarried and postponing parenthood.

As of birth control, Table 9 shows that a woman enjoys more utility flows from using contraceptive methods as they are getting mature. This reflects that contraception use increases with age particularly in female fecund period. Relative to nonwhite females, white females derives more utility flows. This effect could be attributed to the racial disparity in the access to family planning as well as different ethnic culture regarding contraception and out-of-wedlock births. Another interesting aspect regarding the birth control is the number of children ever born increases the utility flows from contraception use. This may reflect that parenting is very time intensive to a woman and she benefits from contraception usage to better budget her time when she already has at least one child. For the similar reason, relative to the number of older children, a woman enjoyed higher utility flow through the usage of contraception with the presence of young children, because without any doubt, young children rearing requires more time investment.

6.2 Goodness of Fit

To measure how well the model describes the data, I compare the women's actual choices with predicted measures of females' occupation choices, marital status, and birth control decisions. The predicted measures are obtained through simulation on the basis of the estimated structural parameters described in the preceding section. The simulation is fairly straightforward: given a particular random draw of the error tem from the extreme value distribution, I simulate relevant choice for every woman over her sample life cycle and then the predicted percentage is computed by averaging over the number of sample members. For each choice measure, I repeat 100 random draws of the error term and average these 100 outcomes over the number of draws.

By and large, the dynamic model fit the data very well. Table 10 presents the actual and the predicted percentages of women's choices and other statistics. As we can see, the actual professional, nonprofessional, and nonworking females account for 25.5 percent, 61.3 percent, and 13.2 percent respectively while the model predicts 24.7 percent, 60.4 percent, and 14.9 percent correspondingly. About 82.3 percent of women choose to use birth control over the sample years which the model slightly overpredicts this measure by 4percent. Chi-square goodness of fit tests do not reject the null hypothesis that the actual number of total person-year is the same at 5percent significance level as those number predicted for both choices. However, as expected, the tests reject the null hypothesis that the predicted and the actual numbers of the total person-year are the same for marriage. Specifically, the model overpredicts total married person-year observations, through the assumption that marriage offer always is available for each women at each period.

7 Conclusions

This study provides a framework for the analysis of women's occupation choices, marriage, and fertility decisions women take over their life cycle, taking into account uncertainty about the future, breaking new ground in two important ways. Given that there is an extensive literature in labor economics recognizes that the life-cycle labor force participation of a woman is highly associated with her family choices, virtually no study going further to incorporate female occupational choices. The model presented in this paper incorporate the role of professional occupation in a dynamic setting with other life-cycle decisions. Another important contribution to the literature is that job offers from different occupations are further modeled to capture uncertainties of the dynamics in the labor market. The estimation results of structural parameters indicate that the life-cycle patterns of occupation, marriage and contraceptive behaviors varies significantly with their observable characteristics such as education, ability, race and strongly depends on the presence of children, especially children younger than 6 years old. This work finds that professional females experienced a substantial reduction in utility as much as three times than that of their nonprofessional counterparts, due to the presence of children younger than 5 years old. Job search cost from other occupations to professionals is much higher than the mobility from other occupations to nonprofessional. This infers that the interruptions of working continuation will blemish a professional woman more than a nonprofessional, and is more costly for professional woman. Therefore, we could expect and rationalize the fact that the fertility pattern of a professional woman is quite different from the other two groups. For example, occupational upward mobility is associated with higher probability of being unmarried and postponing parenthood. Higher AFQT score increases a female's utility flows in dramatic magnitude if she works in a professional occupation. On the contrary, all else equal, the higher AFQT score makes a nonprofessional female's utility flow decreases, which may be due to her unsatisfactory work fulfillment conditional on her higher ability.

It is important to note that incorporating unobserved heterogeneity to the framework of the present paper, the estimated effects of state dependence, or duration effects, in women's choices for occupation, marriage, fertility, and birth control would be expected to be smaller but statistically significant, given the evidence documented by the previous studies on U.S. panel data that spurious state dependence due to unobserved heterogeneity is significant and robust. As discussed previously, the effect of relaxing the assumption that choice-specific error terms are independent over time and individual to allow serially correlated error terms may be ambiguous, and adding unobserved heterogeneity would substantially increased the computational cost of estimating the model presented in this paper, concerning the huge amount of state variables. In this regard, seeking more efficient computational algorithm along with the more complicated dynamic discrete choice model allowing for unobserved heterogeneity and autocorrelation would be left for the future work.

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Table 1: Descriptive Statistics

Variable	Number of Observations	Mean	Standard Deviation
	sample of 622 individuals		
age at 1st period*	622	20.246	1.107
White	622	0.900	0.300
AFQT score	622	58.711	26.482
categorical AFQT	622	2.177	1.045
Protestant	622	0.215	0.411
Catholic	622	0.349	0.477
education at 1st period	622	12.532	2.566
highest grade attended	622	14.280	2.838
professional and managerial in 1982	622	0.138	0.345
non-professional in 1982	622	0.788	0.409
home production in 1982	622	0.074	0.262
	sample of 8708 person-year observations		
age	8708	28.817	4.298
number of children ages 0-5	8708	0.425	0.675
number of children ages 6-12	8708	0.144	0.436
number of children ages 13-18	8708	0.006	0.081
married	8708	0.558	0.497
professional specialty	8086	0.255	0.436
non-professional specialty	8086	0.613	0.487
home production	8086	0.131	0.338
birth control*	7324	0.823	0.376
hourly wage*	4609	10.780	7.654
spouse houly wage	2995	15.896	16.219

* 1. The first observation year for each sample member is defined as the year when she first left school

2. wages are in 1982 dollars
3. Some of the variables are subject to missing data. The statistics presented above are from original sample without imputation.

Table 2: Descriptive Statistics

Variable	Number of Observations	Mean	Standard Deviation
sample of 1400 person-year observations: never married			
age	1400	28.761	4.279
White	1400	0.770	0.421
highest grade attend	1400	14.390	2.857
number of children ages 0-5	1400	0.087	0.322
number of children ages 6-12	1400	0.029	0.187
number of children ages 13-18	1400	0.001	0.027
professional specialty	1300	0.296	0.457
non-professional specialty	1300	0.628	0.483
home production	1300	0.075	0.264
birth control	1039	0.915	0.286
sample of 7308 person-year observations: ever married			
age	7308	28.817	4.298
White	7308	0.925	0.263
highest grade attend	7308	14.259	2.831
number of children ages 0-5	7308	0.489	0.705
number of children ages 6-12	7308	0.166	0.465
number of children ages 13-18	7308	0.007	0.087
professional specialty	6786	0.247	0.431
non-professional specialty	6786	0.611	0.488
home production	6786	0.142	0.349
birth control	6285	0.782	0.431
sample of 2058 person-year observations: ever divorced			
age	2058	28.810	4.304
White	2058	0.918	0.274
highest grade attend	2058	13.694	2.466
number of children ages 0-5	2058	0.399	0.649
number of children ages 6-12	2058	0.156	0.443
number of children ages 13-18	2058	0.009	0.093
professional specialty	1911	0.198	0.399
non-professional specialty	1911	0.653	0.476
home production	1911	0.149	0.356
birth control	1539	0.816	0.371

Table 3: Occupation Distribution of Women, by marital status

Occupational category*	Never Married	Ever Married	Ever Divorced
1. professional	29.62%	24.73%	19.83%
2. non-professional	62.85%	61.05%	65.25%
3. nonworking	7.54%	14.22%	14.91%
Total	100%	100%	100%
N	100	522	147

* 1980 census of population: Standard Occupation Classification System

Table 4: Marital Status of Women, by Occupation

Marital Status	professional	non-professional	nonworking
never married	18.87%	16.23%	9.76%
ever married	81.13%	83.51%	90.24%
proportion of ever divorced	22.48%	30.09%	29.73%
Total	100%	100%	100%
N	159	381	82

Table 5: Occupation and Fertility

	childlessness		number of live births		age at first birth	
	mean	std dev	mean	std dev	mean	std dev
professional	0.353	0.479	1.157	1.076	28.750	4.435
non-professional	0.308	0.463	1.358	1.129	25.449	4.139
non-working	0.082	0.277	2.113	1.172	24.233	3.712
P value of two sample t-test between professional vs other	0.0121		0.0001		0.0013	
N	622		622		622	

Table 6: Occupation, Education and AFQT Score

	Years of Schooling		AFQT Score	
	mean	std dev	mean	std dev
professional	15.907	2.130	68.868	23.826
non-professional	13.433	2.726	53.489	25.765
non-working	13.660	3.051	54.629	28.214
P value of two sample t-test between professional vs other	<0.0000		0.0001	
N	622		622	

Table 7: Estimates of Wage Equation

Variable	Estimate	Std. Error
Women's Wage Equation		
Professional $\ln(w_t^M) = (\delta_1^M)' Z_t + (\delta_2^M)' F_t^M + \delta_3^M p_{t-1}^M + \delta_4^M p_{t-1}^L + \delta_5^M L_{t-1}^M + \delta_6^M L_{t-1}^L + \delta_7^M (L_{t-1}^M)^2 + u_t$		
Constant	-2.094**	0.478
Age	0.105*	0.057
White	0.089**	0.023
AFQT score	0.054*	0.031
Education	0.532**	0.118
Protestan	0.005	0.032
Catholic	0.010	0.046
Unemployment Rate	-0.034	0.102
Average wage earnings	0.076**	0.033
lagged working decision	1.073**	0.375
lagged alternative working decision	-0.159	0.411
Experience	0.984*	0.589
Alternative expreience	-0.778**	0.237
Experience squared	-0.023	0.029
Nonprofessional $\ln(w_t^L) = (\delta_1^L)' Z_t + (\delta_2^L)' F_t^L + \delta_3^L p_{t-1}^L + \delta_4^L p_{t-1}^M + \delta_5^L L_{t-1}^L + \delta_6^L L_{t-1}^M + \delta_7^L (L_{t-1}^L)^2 + v_t$		
Constant	-3.104**	0.899
Age	-0.048	0.053
White	0.056	0.077
AFQT score	0.107	0.100
Education	0.236	0.151
Protestan	0.004	0.025
Catholic	0.007	0.036
Unemployment Rate	-0.213	0.169
Average wage earnings	0.038**	0.007
lagged working decision	1.324**	0.325
lagged alternative working decision	0.632**	0.085
Experience	0.742**	0.223
Alternative expreience	0.233*	0.133
Experience squared	-0.076	0.054
inverse Mills ratio	3.457	0.734
Men's Wage Equation $\ln(w_t^h) = (\delta_1^h)' Z_t^h + (\delta_2^h)' F_t^h + \delta_3^h L_{t-1}^h + \delta_4^h (L_{t-1}^h)^2 + v_t^h$		
Constant	-0.987*	0.517
Age	0.076	0.053
White	0.325**	0.078
AFQT score	0.442**	0.126
Education	0.653**	0.111
Protestan	0.003	0.008
Catholic	0.011	0.032
Unemployment Rate	-0.052	0.044
Average wage earnings	0.087*	0.045
Experience	0.274**	0.099
Experience squared	0.113**	-0.959

Note: * represents significance at 0.10; ** at 0.05 * ** at 0.01 Wage earnings are normalized in terms of 1982 wage level
* Women's wage equation is estimated through Heckman two stage selection model due to the selection bias by only using data on workers. Parameters controlled in the selction equaion include the marital status and presense of young and old children.

Table 8: Estimates of Probit Model of Birth Probability

$$\Pr(n_t = 1 \mid X_{t-1}) = \Phi(\gamma_0 + \gamma_1 g_{t-1} + \gamma_2 g_{t-1}^2 + \gamma_3 b_{t-1} + \gamma_4 m_{t-1} + \gamma_5 N_{t-1} + \gamma_6^{'} p_{t-1} + \gamma_7 w_{t-1}^h m_{t-1} + \gamma_8^{'} w_{t-1} p_{t-1})$$

	Variable	*Estimaties*	*Std. Error*
γ_0	Constant	-1.472*	0.779
γ_1	Age	-0.031	0.023
γ_2	Age squared	-0.044	0.038
γ_3	Lagged birth control	-0.857**	0.097
γ_4	Lagged marital status	0.773**	0.126
γ_5	Lagged number of children ever born	-0.094	0.073
	Lagged working status		
γ_{61}	Profssional	-0.251*	0.129
γ_{62}	Nonprofessional	-0.143	0.131
γ_7	Husband's wage if married	0.064**	0.013
	Female's wage if working		
γ_{81}	Profssional	0.052**	0.017
γ_{82}	Nonprofessional	0.049**	0.019

Note: * represents significance at 0.10; ** represents significance at 0.05.

Table 9: Parameter Estimates of Structure Model

Variable		*Etsimate*	*Std. Error*
Married			
	Constant	-2.612**	0.636
	Age	0.054*	0.032
	White	0.682**	0.034
	AFQT score	-0.017*	0.010
	Education	0.043	0.038
	Protestan	0.018	0.031
	Catholic	-0.002	0.034
	Child age <6	1.064**	0.082
	Child age 6-18	0.072	0.048
	Divorce cost	2.522**	0.884
	Marriage	-1.483**	0.445
	Marriage duration	-0.222**	0.084
Working			
	Professional		
	Constant	-2.786**	0.583
	Age	0.051*	0.031
	White	0.185**	0.033
	AFQT score	0.276**	0.079
	Education	0.063**	0.998
	Protestan	0.199**	0.067
	Catholic	0.143**	0.073
	Child age <6	-3.774**	0.021
	Child age 6-18	-0.271**	0.101
	Job search cost	-3.453**	0.862
	Working experience	0.779**	0.186
	Nonprofessional		
	Constant	-1.071	0.663
	Age	-0.321**	0.116
	White	0.154*	0.089
	AFQT score	-0.417**	0.010
	Education	0.041*	0.023
	Protestan	0.039	0.085
	Catholic	-0.027	0.088
	Child age <6	-1.481**	0.082
	Child age 6-18	-0.383**	0.069
	Job search cost	-1.349*	0.743
	Working experience	0.706**	0.048
Contracepted			
	Constant	-1.232**	0.324
	Age	0.057**	0.021
	White	0.221**	0.058
	AFQT score	0.106*	0.061
	Education	0.027	0.018
	Protestan	0.038	0.033
	Catholic	-0.024	0.019
	Child age <6	0.671**	0.167
	Child age 6-18	0.543**	0.210

Note: * represents significance at 0.10; ** represents significance at 0.05.

Table 10: Actual and Predicted Choices of Selected Measures

Percent of Total Person-Year Observations	Actual	Predicted
working in professional occupation	25.51%	24.67%
working in non-professional occupation	61.34%	60.38%
home production	13.15%	14.95%
Married	55.80%	61.19%
birth control	82.32%	86.32%
Percent of Women Divorced	8.12%	8.72%
Percent of Women Never Married	33.67%	31.67%
Percent of Women having presence of children ages 0-6	32.83%	31.43%
Average Highest Grade Attended	14.28	13.26
Average Number of Birth per Women	0.61	0.65

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