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A STRUCTURAL APPROACH TO ASSESSING RETENTION POLICIES IN PUBLIC SCHOOLS

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Abstract.- One out of five entering public school teachers leave the field within the first four years. Despite that the presence of a newborn child is the single most important determinant of exits of female teachers, retention policy recommendations rely on models that take children as predetermined. This article formulates and estimates a structural dynamic model that explicitly addresses the interdependence between fertility and labor force participation choices. The model with unobserved heterogeneity in preferences for children fits the data and produces reasonable forecasts of labor force attachment to the teaching sector. Structural estimates of the model are used to predict the effects that wage increases and reductions in the cost of childcare would have on female teachers' employment and fertility choices. The estimates unpack important features of the interdependence of fertility and labor supply and contradict previous studies that did not consider the endogeneity between these two choices.

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1 INTRODUCTION

One particular issue that has pervaded policy discussions for decades is the difficulty that US school districts experience in retaining teachers. One out of five entering public school teachers leave teaching within the first four years, citing "personal life factors" as the main reason why they voluntarily leave the job (Goldring et al. 2014; Gray and Taie 2015). While there have been several areas of growth in the literature, one aspect that deserves particular attention is the role of family circumstances, such as maternity and marriage, in explaining teacher mobility patterns. The significance of these factors is consistent with the facts that women make up a dominant portion of total employment in elementary and secondary schools (76% in 2015, NCES 2016) and that female teachers carry smaller wage penalties for labor force interruptions than women in other occupations (Flyer and Rosen 1997; Görlich and Grip 2009; Polachek 1981).

One key question for investigation is, therefore, to what extent fertility is related to teacher mobility patterns and what role it plays at key points over the course of teachers' careers, i.e, attrition and potential return after a spell out of teaching. Another important question concerns the effects of retention policies on labor force attachment to the teaching sector. Answering these questions is relevant given the growing emphasis that school districts are placing on facilitating work and family life balance for young teachers, as well as the lack of empirical evidence on the effects of these efforts on retention.[1] Addressing these issues requires an understanding of the dynamics of female teachers' choices, how unobserved fertility preferences affect the sorting into different career paths, and how intermittency patterns, work decisions, and fertility choices interact with each other.

This paper targets these questions by constructing and estimating a structural dynamic model that explicitly addresses the interdependence between fertility and labor force participation choices. The proposed model builds on the early works by Stinebrickner (2001a, 2001b) by allowing the certified teacher to choose a labor activity from among a set of teaching, non-teaching, and leisure options. This paper, however, differs in the modeling approach toward fertility. While Stinebrickner (2001a, 2001b) assumes fertility is exogenous or stochastic, I construct a dynamic setting that endogenizes fertility. Hence, this model integrates occupational and fertility choices into a female teacher's life cycle plan, where women with different taste toward childbearing opt for different occupations so as to balance their career path with family formation choices. With this framework, I generate predicted life-cycle trajectories for employment status, wages, and fertility that match the observed ones. The behavioral parameters of the model are recovered through the Method of Simulated Moments (MSM)

[1] Despite the fact that many school districts have begun to offer child care benefits, to my knowledge, no prior studies have provided empirical evidence regarding their effects on retention.

using data from the National Longitudinal Study of the High School Class of 1972 (NLS-72) and are used to simulate the effects that potential wage changes and reductions in the cost of childcare would have on female teachers' employment and fertility decisions.

The joint nature of fertility and female labor supply decisions has long been recognized and discussed.[2] However, none of this literature pertains to teachers.[3] The issue of teachers and mobility takes on particular importance for two reasons. First, teaching has a relatively high turnover rate compared to other occupations (Harris and Adams 2007; Ingersoll 2001, 2002). The higher mobility observed among teachers remains when exits are associated with childbirth (Stinebrickner 2002). Second, schools that experience high mobility appear to have lower student achievement (Kane and Staiger 2008; Levy et al. 2012; Rivkin et al. 2005; Ronfeldt et al. 2013).[4]

The negative effect of childbearing on teacher employment has been described in both duration models (Flyer and Rosen 1997; Frijters et al. 2004; Scafidi et al. 2006; Stinebrickner 1998, 2002) and dynamic frameworks (Stinebrickner 2001a, 2001b). However, while these studies are an important step forward, they assume that the presence of children is exogenous (with the exception of Stinebrickner 2001b, who models births stochastically), and thus have substantial limitations. First, they may overestimate the effect of children on attrition.[5] Second, they disregard the potential effects that policy initiatives may have on fertility. To the extent that fertility and employment are jointly determined, ignoring a channel through which policies may affect employment inevitably leads to inaccurate policy recommendations.

The structural model enables this article to disentangle and thus understand the true impact that labor and fertility decisions have on each other along teachers' career paths. Estimates indicate that gains of career interruptions due to childbirth vary between 83% and 98% of the teaching wage if departure occurs within five years after certification, and that reentry penalties for nonworking women with children lie between one and two times the teaching wage.

The results of this article are in stark contrast with the work by Stinebrickner (2001b), whose estimates indicate that childcare subsidies would not be a cost effective policy when

[2]Early papers, which apply a reduced-form approach, include Cain and Dooley (1976), Hotz and Miller (1988), Moffitt (1984), and Schultz (1990). More recent papers, which use dynamic life-cycle models, include Adda et al. (2017), Francesconi (2002), Gayle and Miller (2012), Keane and Wolpin (2010), and Sheran (2007).

[3]There is a trend in the literature toward estimating structural models for the specific population of teachers. For instance, van der Klaauw (2012) and Ni and Podgursky (2016) use this approach to evaluate subjective expectations and pension systems, respectively.

[4]In schools with high rates of attrition, students may be more likely to have inexperienced teachers who, on average, are less effective (Kane et al. 2008; Rivkin et al. 2005; Rockoff 2004).

[5]This would occur if, for instance, job unhappiness makes individuals more likely to leave work to have children. The overestimation arises because a model in which children are treated as predetermined could not take into account that individuals with more children would be, on average, more likely to leave work (than individuals with fewer children), even if they had the same number of children.

dealing with retention problems, given the large negative effect that children have on the utility of teachers. By allowing fertility and labor supply to be jointly determined, on the other hand, this study's estimates indicate that giving teaching-employed women subsidies to offset childcare costs would reduce fertility-related career interruptions, and thus contribute to increasing retention.

The presented policy simulations also illustrate how different fertility responses to exogenous changes in women's environments yield increases in retention. Wage increases have a negative effect on fertility, and thus decrease exits related to childbirth. Reductions in the cost of childcare, on the other hand, increase fertility and are shown to be effective in increasing job attachment to the teaching sector among beginner teachers as more teaching jobs and births are simultaneously chosen at early periods.

Previous research has established a strong and positive relationship between teacher pay and the length of time that teachers remain in their first teaching job.[6] Relatively few studies, however, have examined which factors affect teachers' decisions to return to the profession. Most of the work done on this topic has been limited to descriptive or analytical single-state studies, which used administrative data that contained no information about the labor force status of individuals after they left teaching, or about family formation variables (Beaudin 1993; DeAngelis and Presley 2007; Kirby et al. 1991; Murnane et al. 1988; Plecki et al. 2006). Only a few studies used longitudinal data containing family variables to explore the reentry decision (Grissom 2012; Stinebrickner 2002). None of these studies, however, established an empirical link between family-oriented policies and the potential decision to reenter the profession.[7]

The remainder of this article is set out as follows. Section 2 outlines the model. Section 3 introduces the data and describes the salient characteristics of the sample. The estimation methodology is presented in Section 4. The estimation results and the model fit are discussed in Section 5. The policy simulations are presented in Section 6, and Section 7 concludes.

2 THE DYNAMIC MODEL

Each female teacher has a finite decision horizon beginning at age (A_0), the age she is the year after certification, and exogenously ending T years later. At each age t, she chooses

[6]See Murnane and Olsen (1989, 1990), Gritz and Theobald (1996), Stinebrickner (1998), Dolton and van der Klaauw (1999), Boyd et al. (2005), and Li (2009) for an examination of the issue in reduced-form models and Stinebrickner (2001a, 2001b) for an overview of teacher attrition in a dynamic setting.

[7]Grissom (2012) finds that former female teachers are less likely to reenter with young children at home, suggesting that childcare assistance policies would increase reentry of former teachers. Frijters et al. (2004) and Scafidi et al. (2006) also mention a day care subsidy for women with young children as a policy alternative, but rely on Stinebrickner's (2001b) results to conclude that this may not be a cost-effective policy.

whether she works in a teaching job or not, whether she works in a nonteaching job or not, and whether she has a child or not. A birth may occur in any period during the fertile stage, which exogenously ends at age 40. Therefore, a female teacher faces six mutually exclusive alternatives denoted by j: $j = 1$ if teaching and no birth; $j = 2$ if teaching and birth; $j = 3$ if nonteaching and no birth; $j = 4$ if nonteaching and birth; $j = 5$ if nonworking and no birth; and $j = 6$ if nonworking and birth. Let $d_{jt} = 1$ if alternative j is chosen at time t and $d_{jt} = 0$ otherwise. All alternatives are mutually exclusive, implying $\Sigma_{j=1}^{6} d_{jt} = 1$. At any age t, the objective of a particular female teacher is to maximize the expected present value of remaining lifetime utility,

$$E_t \left[\sum_{t=A_0}^{A_0+T} \delta^{t-A_0} U_t(c_t, e_t, n_t, k_t, K_t) \right], \tag{1}$$

with respect to e_t, n_t, and k_t for ages $t = A_0, \ldots, 40$ and with respect to e_t and n_t for ages $t = 41, \ldots, A_0 + T$. The variables are defined as follows: c_t is the level of goods consumption at t; e_t is a dichotomous variable equal to unity if the female teacher works in a teaching job and equal to zero otherwise; n_t is a dichotomous variable equal to unity if the female teacher works in a nonteaching job and equal to zero otherwise; $k_t = 1$ indicates a birth at t and $k_t = 0$ indicates no birth; K_t represents the total number of children at age t; $\delta \,\epsilon [0, 1]$ is the subjective discount factor; and E_t is the expectations operator.[8]

Per period utility at any age t, U_t, is assumed to have the following form:

$$U_t = c_t + a_{1t} e_t + a_{2t} n_t + b_t + g_{1t} e_t + g_{2t} n_t. \tag{2}$$

The disutilities of working in teaching and in nonteaching without children (a_{1t} and a_{2t}, respectively), the direct utility obtained from having children (b_t), and the difference in the disutilities of teaching and of nonteaching when having children instead of being childless (g_{1t} and g_{2t}, respectively) are further parameterized as functions of age and the stock of children as follows:

$$a_{lt} = \alpha_{l1} + \alpha_{l2} t + \alpha_{l3} t^2, \qquad l = 1, 2 \tag{3}$$

$$b_t = \beta_1 K_t + \beta_2 K_t t + \beta_3 K_t t^2 + \beta_4 K_t^2 + \beta_5 K_t^2 t + \beta_6 K_t^2 t^2 \tag{4}$$

$$g_{lt} = \gamma_{l1} K_t + \gamma_{l2} K_t t + \gamma_{l3} K_t t^2 + \gamma_{l4} K_t^2 + \gamma_{l5} K_t^2 t + \gamma_{l6} K_t^2 t^2, \qquad l = 1, 2 \tag{5}$$

Thus, the utility in equation 2 is decreasing in e_t and n_t, reflecting disutility of working in teaching ($\alpha_{11} < 0$) and in nonteaching ($\alpha_{21} < 0$). Labor market decisions interact with age through α_{12}, α_{13}, α_{22}, and α_{23}. The parameters β capture the effects that children have on utility. I expect that a larger number of children provides a higher instantaneous utility

[8]To limit the size of the state space, the maximum number of children allowed in the model is three. Consequently, giving birth during the fertile stage is an option provided the individual has fewer than three children at the beginning of the decision period.

($\beta_1+\beta_2 t+\beta_3 t^2 > 0$) at a decreasing rate ($\beta_4+\beta_5 t+\beta_6 t^2 < 0$). The effect that children have on utility through their interactions with current participation is represented in the parameters γ. The disutility of working in both sectors when children are present is expected to be greater than the disutility of working while being childless. That is, I expect g_{1t} and $g_{2t} < 0$. This in turn implies that the marginal utility of children in the nonmarket alternative is expected to be greater than the gains of children in both teaching and nonteaching sectors.

I incorporate persistent unobserved individual differences in preferences for children following an approach similar to that proposed by Heckman and Singer (1984). Specifically, unobserved heterogeneity arises in the utility function through β_1, allowing women to differ in their direct utility of children, b_t. The distribution of the time-invariant heterogeneity component, β_1, is specified to be discrete joint multinomial. Accordingly, I distinguish between J 'types' of individuals where each type j, $j = 1, \ldots, J$, is characterized by a different value of β_1. The population proportions of each type are given by $p_j = Pr(\beta_1 = \beta_{1j})$, $j = 1, \ldots, J$. In the specification of the model I allow for two types of individuals, who differ in the values of β_1 according to their preferences toward childbearing.[9] The proportions of women with low and high preferences for children are defined as $Pr(\beta_1 = \beta_{11}) = p_1$ and $Pr(\beta_1 = \beta_{12}) = 1 - p_1$, respectively.

The proposed model generates two different sources of children gains that depend on the number of children and the women's age.[10] The first one, "*children premia*," is relevant to understanding quitting behavior. It measures the gains that a teaching-employed woman receives if she keeps her current teaching job and gives birth, as well as the gains she receives if she leaves teaching and bears a child.[11] My results are expected to be consistent with previous literature that has found that attrition is positively related to childbirth. Thus, I expect the gain of dropping entirely out of the workforce to give birth to be greater than the gain of keeping a current teaching job and giving birth. Although the sign of the utility flows of switching to nonteaching associated with childbirth cannot be predetermined, it is expected that if positive, the gains of dropping out of the workforce entirely will be greater than the gains of switching to the nonteaching sector to give birth.

The second source of children gains, "*occupation premia*," measures the nonpecuniary gains of employment alternatives conditional on having children, and gives insight into two

[9] See van der Klaauw (1996, 2012) for a similar specification of the unobserved heterogeneity distribution.

[10] Children gains are based on contemporaneous utility rather than discounted expected lifetime utility. Thus, they only capture the gains (or losses) incurred in a particular period and do not account for future choices.

[11] Let q_{1t}, q_{2t}, and q_{3t} be the contemporaneous utility independent of consumption, $U_t - c_t$, when $e_t = 1, n_t = 1$ and ($e_t = 0$ and $n_t = 0$), respectively. The gains of giving birth while employed in a teaching job have been calculated as $q_{1t}(K_t + 1) - q_{1t}(K_t)$ and the gains of switching to nonteaching and of leaving the workforce altogether to give birth have been calculated subtracting $q_{1t}(K_t)$ from $q_{2t}(K_t + 1)$ and $q_{3t}(K_t + 1)$, respectively. These premia are evaluated for $K_t = 0, 1, 2$.

points.[12] First, it reflects how children affect the disutility of working. The disutility of teaching and nonteaching are expected to be greater with more children. Second, when evaluated at late periods, it measures the gains and losses of a reentry into teaching associated with prior fertility behavior. For instance, the gains of teaching relative to nonteaching reflect the rewards that an average former teacher with children and enrolled in a nonteaching job receives if she returns to teaching. The gains of teaching relative to the nonmarket alternative, on the other hand, provide information about the rewards incurred by a nonworking former teacher with children if she returns to teaching.[13]

The choice decision in each period as described in equation 1 is made subject to the woman's budget constraint, which is assumed to be satisfied period by period, and is given by:

$$w_{1t}e_t + w_{2t}n_t \;=\; c_t + f_1 e_t + f_2 n_t + f_3 K_t, \qquad (6)$$

where w_{1t} and w_{2t} denote the female teacher's wage earnings in teaching and nonteaching, respectively; f_1 and f_2 represent the corresponding fixed costs of work, and f_3 is the goods cost per child.

The female teacher's current earnings depend on the initial wage draw and age t. They are given by:[14]

$$w_{lt} \;=\; \omega_l \exp\left(z_{l1}\, t + z_{l2}\, t^2\right), \qquad l \;=\; 1,\, 2, \qquad (7)$$

where ω_1 and ω_2 are drawn from truncated lognormal wage offer distributions $F_1(x)\,:\, ln\, x \,\sim\, N(\mu_1, \sigma_1^2 \,|\, ln\, \underline{\omega}_1, ln\, \overline{\omega}_1)$ and $F_2(x)\,:\, ln\, x \,\sim\, N(\mu_2, \sigma_2^2 \,|\, ln\, \underline{\omega}_2, ln\, \overline{\omega}_2)$, respectively. That is, when employed, the individual experiences wage growth as a function of age, which captures the accumulation of human capital over time.[15]

The assumption that the female teacher does not carry over any debt incurred during one period to the next period is extreme. However, given that the instantaneous utility function in equation 2 is linear and additive in consumption, the above optimization problem becomes a lifetime wealth maximization problem modified by the psychic value of children and work (Eckstein and Wolpin 1989; Francesconi 2002).

[12] Let q_{1t}, q_{2t}, and q_{3t} be the contemporaneous utility independent of consumption, $U_t - c_t$, when $e_t = 1, n_t = 1$ and ($e_t = 0$ and $n_t = 0$), respectively. The gains of teaching relative to nonteaching and to out of the workforce have been calculated as $q_{1t}(K_t) - q_{2t}(K_t)$ and $q_{1t}(K_t) - q_{3t}(K_t)$, respectively. The benefit of nonteaching relative to out of the workforce has been calculated as $q_{2t}(K_t) - q_{3t}(K_t)$. These premia are evaluated for $K_t = 1, 2, 3$.

[13] Considering that most individuals start their working career with a teaching job (74% in the data) and that the average first teaching spell is 3.3 years, these premia, although not conditioned on a previous career interruption, provide an idea of gains and losses of returning to teaching associated with prior fertility behavior.

[14] CPI is used to deflate nominal wage values into 1986 dollar values.

[15] Modeling wage as functions of experience would have been preferable, but would also increase the computation burden to solve and estimate the model. Rendon (2007) and Rendon and Quella-Isla (2015) also assume age-specific wages in structural models of job search.

The set of available employment options in a given year depends on the person's employment status in the previous year. If in $t-1$ the individual is employed as a teacher, in t she can continue working in her previously held job, accept a new nonteaching job offer drawn from the known wage offer distribution $F_2(.), (x_2 \in (\underline{\omega}_2, \overline{\omega}_2), 0 < \underline{\omega}_2 < \overline{\omega}_2 < \infty)$, or choose the nonmarket alternative.[16] Likewise, if in $t-1$ the person is employed in a nonteaching job, in t she can continue working in her previously held job, accept a new teaching job offer drawn from the known wage offer distribution $F_1(.)(x_1 \in (\underline{\omega}_1, \overline{\omega}_1), 0 < \underline{\omega}_1 < \overline{\omega}_1 < \infty)$, or choose the nonmarket alternative. If in $t-1$ the person is out of the workforce, in t she receives a teaching job offer with probability ρ and a nonteaching job offer with probability $1-\rho$. Both job offers are drawn from the known wage offer distributions $F_1(.)$ and $F_2(.)$, respectively. The person also has the option of staying out of the workforce.

Contraception is assumed to be perfect during the fertile stage and births are timed without error. The total number of children at age t, K_t, is a time-varying predetermined state variable that evolves as $K_t = K_{t-1} + k_t$. At the time of each period's work decision the woman knows the value of her current occupation's base wage (ω_l) for $l = 1, 2$, the distribution of the wage offer from the alternative occupation, and the wage structure in equation 7, but does not know the future realizations of the wages in the alternative occupation.

The decisions made at age t depend on the fertility and employment histories up to that point in time. This history defines the state at which a female teacher starts a new period. The state space is denoted as $\Omega_t = (K_{t-1}, A_0, j_{t-1},\ \omega_1\ I(e_{t-1} = 1),\ \omega_2\ I(n_{t-1} = 1))$.

Let the value function $V_t(\Omega_t)$ be the maximal expected present value of lifetime utility as in equation 1 given the woman's state Ω_t. The value function can be written as the maximum over alternative-specific value functions, that is,

$$V_t(\Omega_t) = \max[V_{1t}(\Omega_t), \ldots, V_{6t}(\Omega_t)], \qquad t = A_0, \ldots, 40,$$

and

$$V_t(\Omega_t) = \max[V_{1t}(\Omega_t), V_{3t}(\Omega_t), V_{5t}(\Omega_t)], \qquad t = 41, \ldots, A_0 + T,$$

where $V_{jt}(.)$ is the value function if the female teacher chooses alternative j. Each of these alternative-specific value functions obey the Bellman equation (Bellman, 1957):

$$\begin{aligned} V_{jt}(\Omega_t) &= U_{jt}(\Omega_t) + \delta E_t V_{t+1}(\Omega_{t+1}|\Omega_t, d_{jt} = 1), \qquad t < A_0 + T \\ V_{j,A_0+T}(\Omega_{A_0+T}) &= U_{j,A_0+T}(\Omega_{A_0+T}), \end{aligned} \tag{8}$$

with $j = 1, \ldots, 6$ for $t = A_0, \ldots, 40$ and $j = 1, 3, 5$ for $t = 41, A_0 + T$. The expectation in equation 8 is taken with respect to the realization of the stochastic earnings conditional on Ω_t and $d_{jt} = 1$. Appendix A describes in detail the numerical solution of the model.

[16] Given that during the sample period of the data few teachers were laid off, I do not find it restrictive to assume that all individuals currently teaching will always have the option to remain in teaching.

3 DATA

The data come from the NLS-72. This survey collected longitudinal data on the post-secondary educational activities of 22,652 high school seniors who graduated in 1972 and included five additional follow-up surveys through 1986. For each person, the survey contains detailed information on the timing of employment spells and birth events. The analysis in this study will be restricted to the subsample of 405 female teachers who became certified to teach at some point between 1975 and 1985 and that had teaching experience after certification.

While the final 1986 follow-up survey was limited to only a subset of the original NLS-72 participants, the sample design oversampled teachers and potential teachers by including all those who had previously reported having completed teaching training. Therefore, the NLS-72 surveys combined provide a valuable source for the study of mobility patterns of a cohort of teachers.[17] A valid concern regarding my results is that the data represent preferences of teachers of several generations past. However, studies that used more current data illustrate that family circumstances remain important determinants of teacher mobility (Scafidi et al. 2006 with data from the 90s and Grissom 2012 with the NLSY-79, which contains information on workers throughout the 1980s and 1990s and into the 2000s).[18]

In any given year, a woman is defined to be working if she is employed for more than 20 hours per week at any time between the first of November of the previous year and end of October of the current year.[19] A woman's wage earnings are defined as her weekly wage rate times 52 weeks.[20] She is defined to give birth in a given year if a birth occurs between the first of November of the previous year and end of October of the current year. For non-interview years, the employment and fertility histories were obtained using retrospective questions from the last follow-up survey. Table 1 reports descriptive statistics for the sample. The first observation year is the year following certification, and the last sample year is 1986. For the resulting unbalanced panel, the average sample member is observed for 10 years, resulting in 4,455 "person-years."[21] The majority of individuals in the sample do not have children

[17]The 1993-03 Baccalaureate and Beyond Longitudinal Study is a more current survey specific to teachers. However, this survey does not track fertility choices. Considering the important role fertility plays in explaining teacher mobility patterns, the NLS-72 is the survey that best fits the objectives of this study.

[18]One exception is the work by Gilpin (2011) with data of the Teacher Follow Up Survey for school years 2000-2001 and 2004-2005. He found that the majority of former teachers, regardless of teaching experience, remain working outside of teaching, in contrast to exiting the labor force entirely.

[19]In teaching labor markets, it is uncommon for working terminations to occur in the middle of a school year. Also, the "out of the workforce" designation includes individuals who are working fewer than 20 hours a week. The same approach is taken by Stinebrickner (2002).

[20]For some years, wages were reported other than weekly. In these cases, weekly wages were calculated by dividing annual salary by 52 weeks, monthly salary by 4.6 weeks, or multiplying hourly wages by the number of hours worked per week.

[21]Since this article focuses on career choices after certification, and most individuals spent four years after high school in training courses to be certified, the final data set contains between one and eleven years of information for every individual. Most individuals are observed for ten or fewer years; only those who spent

when they initially become certified to teach. The average female teacher is 27 years old, has two children, and earns \$303 per week in a teaching job and \$296 per week in a nonteaching job. Nonteaching earnings are more dispersed than teaching earnings, reflecting the fixed structure of wages in the teaching sector. The lower part of table 1 further shows that of the 4,455 person-years, 53% are spent in teaching without giving birth, 5% in teaching giving birth, 13% working in nonteaching without giving birth, 1% in nonteaching giving birth, 12% not working and not giving birth, and 3% not working and giving birth.

TABLE 1
Descriptive Statistics

	Mean	Std. Dev	No. of obs.
Sample of 405 individuals			
Years in sample	9.54	1.60	405
Age in 1st period	22.07	1.77	405
Percent with at least one child (in $t = 0$)	7.90	-	405
Percent with at least one child (in 1986)	72.35	-	405
Number of children (in $t = 0$)[a]	0.10	0.37	405
Number of children (in 1986)[a]	1.06	0.67	405
Sample of 4,455 person-year observations			
Age	27	3.62	4,455
Number of children[b]	1.55	0.66	1,358
Teaching Wage [c]	302.54	99.59	2,565
Nonteaching wage [c]	295.54	143.56	638
Teaching and no birth	60.97	-	4,455
Teaching and birth	5.41	-	4,455
Nonteaching and no birth	15.27	-	4,455
Nonteaching and birth	1.24	-	4,455
Nonwork and no birth	13.43	-	4,455
Nonwork and birth	3.67	-	4,455

[a] Computed for all individuals observed in t.
[b] Computed on person-years observations with positive number of children only.
[c] Computed on person-years observations with positive sector-specific earnings.

Figure 1 illustrates how the employment participation rates of female teachers changes over time after certification and provides some descriptive insight into the extent of and reason for teacher attrition. During years of decline in teaching participation, the participation rate in nonteaching occupations remains largely unchanged, suggesting that a large increase in the proportion of women who are out of the workforce plays a more important role in the declining teaching participation rate.

three years in college are observed for eleven years.

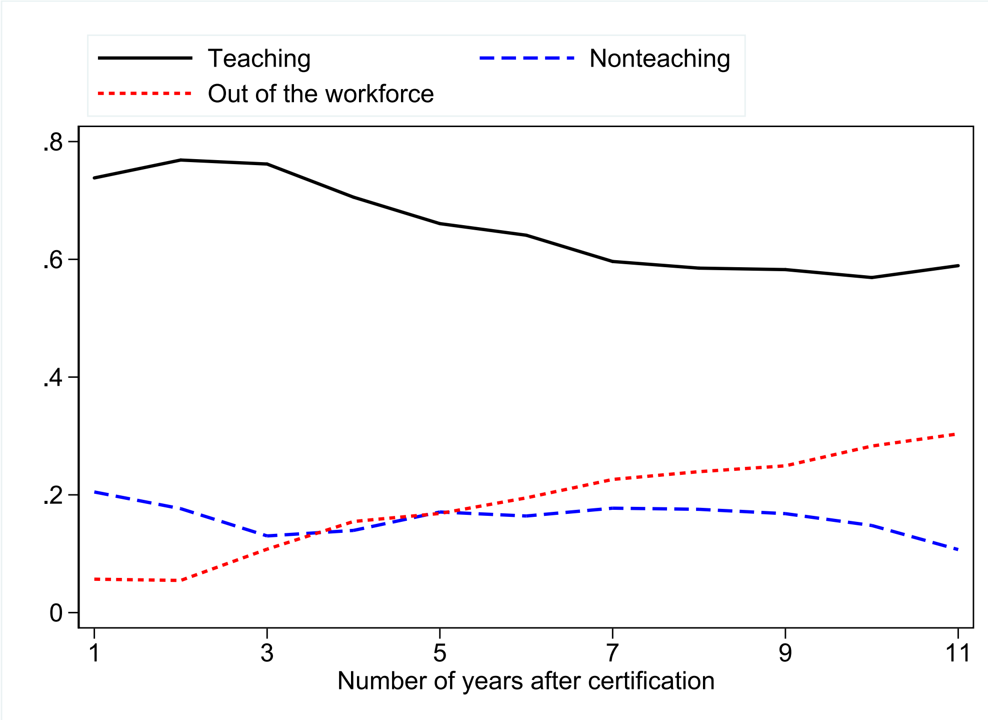


FIGURE 1
Actual Participation Rates

Table 2 shows the evolution of employment rates and employment transitions, as well as wages 2, 4, 6, 8, and 10 years after certification. Employment distributions correspond to the participation rates shown in Figure 1. Increasing birth rates complement the trends observed in the employment distributions and support the view of thinking of attrition as a fertility-related event. Moreover, the fact that birth rates increase in mid-career years while departures from teaching to the nonmarket alternative decrease suggests that births are likely to occur within one or two years after dropping out of teaching.

Other employment transitions give some insight into reentry behavior. Higher transition rates into teaching in early years reflect the fact that some individuals do not work as teachers right after certification,[22] and also suggest that reentry into teaching after a career interruption is not very likely to occur. The large share of women who keep their nonteaching job from the previous period, as well as the large proportion of nonworking women who remain out of the workforce the following period, suggest that once individuals leave teaching, they are less likely to return.[23]

[22]Recall that transitions into teaching can represent both a first entry into teaching or a reentry after a spell out of teaching. In the data, 26% of individuals do not start their careers employed as teachers.

[23]Caution should be taken when interpreting reentry behavior in the data. The average teacher is 32 years old in her last year observed. Neither her fertility cycle nor her potential years to return have ended. An analysis of attrition and reentry patterns indicates that 38% of all exiting teachers who are observed five or more years after leaving the workforce return at some point within this period. The percentage of the

TABLE 2
Employment, Fertility and Wages by number of years since certification

	Years after certification				
Variable	Year 2	Year 4	Year 6	Year 8	Year 10
Employment Distributions					
Teaching	76.87	70.56	64.10	58.51	56.91
Non Teaching	17.66	13.96	16.41	17.55	14.80
Out of the workforce	5.47	15.48	19.49	23.94	28.29
Employment Transitions					
From teaching					
To teaching	87.16	84.28	89.92	93.72	91.71
To nonteaching	7.43	5.35	3.10	2.24	1.10
Out of the workforce	5.41	10.37	6.98	4.04	7.18
From nonteaching					
To teaching	45.78	26.92	10.61	5.88	2.00
To nonteaching	51.81	67.31	81.82	79.41	84.00
Out of the workforce	2.41	5.77	7.58	14.71	14.00
From out of the workforce					
To teaching	56.52	27.91	16.67	8.24	8.22
To nonteaching	26.09	9.30	3.03	8.24	1.37
Out of the workforce	17.39	62.79	80.30	83.53	90.41
Birth Rate	3.48	8.63	15.90	16.49	5.59
Mean wage in teaching	15,180	14,615	14,223	18,218	17,711
Mean wage in non teaching	13,402	14,461	14,501	18,071	18,993
Mean wage	14,848	14,590	14,279	18,184	17,976
Wage Distribution					
w <11,856	20.79	30.93	38.22	11.19	11.47
11,856=< w <15,444	35.79	36.04	24.84	17.48	17.89
15,444=< w <18,876	25.00	16.82	16.88	24.83	29.36
w >=18,876	18.42	16.22	20.06	46.50	41.28

NOTE.- Employment transitions consider flows from period $t-1$ to period t.

4 ESTIMATION

The estimation strategy is designed to recover the behavioral parameters of the theoretical model. I use the starting point of each individual in the data as the starting point of

subset of women who leave the workforce after giving birth is 30%. It seems possible, then, that an increase in the return rates would occur after year 6 when the teacher feels comfortable with childcare or when the child becomes old enough to attend school. Unfortunately, whether this occurs or not, cannot be examined with these data.

individuals in my simulated sample, which is composed of 20 "copies" of every individual in the data. Overall, I simulate 89,100 career and fertility paths.[24]

Consider a woman who, one year after becoming certified to teach, begins her working career at age A_0. Given her state space, Ω_t, the woman draws a random shock from $F_1(.)$ or $F_2(.)$, calculates the six current utilities and the alternative-specific value functions, and chooses the alternative that yields the highest value. The state space is then updated according to the alternative chosen, and the process is repeated. Exact numerical solution is carried out by backward induction (value function iterations). Agents solve the dynamic problem with a finite horizon $T = 40$.[25]

The solution to the optimization problem serves as the input into estimating the structural parameters of the model given data on choices and earnings. From the alternative-specific value functions, all structural parameters can be estimated, except that the utility parameters β_{11}, β_{12}, β_4, and γ_{l1}, γ_{l4}, α_{l1}, for $l = 1, 2$, cannot be distinguished from the budget parameters f due to data limitations. The identifying restriction is then $f_1 = f_2 = f_3 = 0$. This implies that α_{l1} for $l = 1, 2$ should be interpreted as the gross costs of work (normalized to dollars), while the β and γ parameters measure the value of children net of the goods cost of children.[26]

The model is estimated using the MSM (see Pakes and Pollard 1989, and Duffie and Singleton 1993). Based on an initial set of parameters, I solve the dynamic programming problem and then simulate paths of employment and fertility. The simulated data provide a panel dataset used to construct moments that can be matched to moments obtained from the observed data. Using a quadratic loss function that measures the distance between the observed and simulated moments, the parameters of the model are then chosen such that the simulated moments are as close as possible to the observed moments. The parameters to be estimated are $\phi = \{\beta_{11}, \beta_{12}, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \rho, p_1, \Theta\}$ where $\Theta = \{\alpha_{l1}, \alpha_{l2}, \alpha_{l3}, \gamma_{l1}, \gamma_{l2}, \gamma_{l3}, \gamma_{l4}, \gamma_{l5}, \gamma_{l6}, \mu_l, \sigma_l, z_{l1}, z_{l2},\}$ for $l = 1, 2$.

The moments used in this estimation are the cell-by-cell probability masses for the following distributions:

1. employment status (3 moments $\times$ 11 years),
2. wage levels (4 moments $\times$ 11 years),
3. children statuses (4 moments $\times$ 11 years),

[24] That is, the starting point of individual i in the data is used as the starting point of individuals $i, \ldots, 20 \times (i-1) + j$ in the simulated sample, where $j = 1, \ldots 20$.

[25] That is, the model ends 40 years after the woman is certified. For instance, a woman who starts her working career at age of $A_0 = 25$, makes employment and fertility decisions during the first 15 years of her working career (until she is 40), but only employment decisions for the remaining 25 years.

[26] As long as the budget parameters are linear in e_t, n_t and K_t (as in equation 6), they are not distinguishable from their respective psychic values in the utility function, α_{11} and α_{21}.

4. employment transitions from teaching (3 moments $\times$ 10 years),
5. employment transitions from nonteaching (3 moments $\times$ 10 years),
6. employment transitions from the nonmarket alternative (3 moments $\times$ 10 years),
7. fertility transitions for childless women (2 moments $\times$ 10 years),
8. fertility transitions for women with one child (2 moments $\times$ 10 years),
9. fertility transitions for women with two children (2 moments $\times$ 10 years),
10. attrition rates (11 moments $\times$ 10 years),
11. return rates from nonteaching (2 moments $\times$ 10 years),
12. return rates from out of the workforce (2 moments $\times$ 10 years).

Thus, there are 421 moments to estimate 35 parameters. The MSM procedure relates a parameter set to a weighted measure of distance between sample and simulated moments:

$$S(\phi) = \Delta m' W^{-1} \Delta m,$$

where Δm is the distance between each sample and simulated moment and W is a weighted matrix. In this study, W is an identity matrix and each moment is weighted the same. The estimated behavioral parameters are thus $\phi^* = \operatorname{argmin} S(\phi)$. The function is minimized using Powell's method (Powell 1964), which requires function evaluations, not derivatives.

5 RESULTS

5.1 Parameter Estimates

Table 3 presents the estimates and asymptotic standard errors of the structural parameters assuming a discount factor, δ, of .95. Teaching jobs present a lower mean and standard deviation of the log-wage offer distribution than nonteaching jobs. These parameters imply an estimated mean yearly wage offer for teaching jobs of \$10,043 and of \$10,574 for nonteaching jobs. The wage growth parameters show that wages grow at a declining rate for both teaching and nonteaching occupations.

TABLE 3
Parameters Estimates and asymptotic standard errors

Parameter	ϕ	Estimate	SE
Teaching Pecuniary Utility			
Mean of log wage dbn:	μ_1	9.163	0.675*
St. dev. of log wage dbn:	σ_1	0.319	0.071*
Wage growth (linear):	z_{11}	0.004	0.000*
Wage growth (quadratic):	z_{12}	-0.001	1.191
Nonteaching Pecuniary Utility			
Mean of log wage dbn:	μ_2	9.123	1.499*
St. dev. of log wage dbn:	σ_2	0.535	0.294*
Wage growth (linear):	z_{21}	0.038	0.000*
Wage growth (quadratic):	z_{22}	-0.006	0.000*
Teaching Non-pecuniary			
Constant:	α_{11}	-7,690.61	2,252.91*
Year:	α_{12}	-2.101	0.334*
Year ×Year:	α_{13}	7.957	0.931*
Number of children:	γ_{11}	113.451	29.951*
Number of children growth (linear):	γ_{12}	3.268	0.671*
Number of children growth (quadratic):	γ_{13}	-54.738	4.795*
Number of children^2:	γ_{14}	-65.655	3.833*
Number of children^2 growth (linear):	γ_{15}	-47.755	3.228*
Number of children^2 growth (quadratic):	γ_{16}	-8.829	2.078*
Nonteaching Non-pecuniary			
Constant:	α_{21}	-15,518.58	4,103.4*
Year:	α_{22}	41.285	3.393*
Year ×Year:	α_{23}	11.176	0.747*
Number of children:	γ_{21}	206.818	5.704*
Number of children growth (linear):	γ_{22}	37.544	9.703*
Number of children growth (quadratic):	γ_{23}	-61.655	9.116*
Number of children^2:	γ_{24}	-13.221	0.708*
Number of children^2 growth (linear):	γ_{25}	-35.355	5.652*
Number of children^2 growth (quadratic):	γ_{26}	19.743	4.714*
Children			
Number of children growth (linear):	β_2	2.098	0.099*
Number of children growth (quadratic):	β_3	67.169	18.317*
Number of children^2:	β_4	-14.164	1.394*
Number of children^2 growth (linear):	β_5	1.332	0.096*
Number of children^2 growth (quadratic):	β_6	-21.863	1.908*
Unobserved heterogeneity			
Number of children:	β_{11}	155.634	25.332*
Number of children:	β_{12}	198.096	16.398*
Type proportion			
Prob type 1:	p_1	0.363	0.513*
Labor Market			
Prob offer if out workforce:	ρ	0.601	0.024*

NOTE: * denotes an asymptotic t ratio greater than two.

The nonpecuniary parameter estimates seem to be consistent with others available in the literature. For example, participation decreases utility (α_{11} and $\alpha_{21} < 0$), particularly in nonteaching employment. Francesconi's (2002) and Eckstein and Wolpin's (1989) estimates also indicate a disutility of working for a sample of married women observed between 1968 and 1991, and between 1967 and 1982, respectively.[27] Using NLSY data, Sheran (2007) also finds that the utility of women decreases with a full time job.

As expected, estimates show that marginal utilities are positive and diminishing in children ($\beta_{11}, \beta_{12}, \beta_2, \beta_3 > 0$ and $\beta_4 + \beta_5 t + \beta_6 t^2 < 0 \ \forall t$), vary across types substantially, and are always greater in the nonmarket alternative.[28] For instance, the monetary (utility) value of the first child in the nonmarket alternative for a woman at age 23 is estimated to be \$560 for women with low taste for children (LF) and \$602 for women with high taste for children (HF). A second child would decrease these gains at the same age to \$146 and \$188 for women with low and high preferences toward children, respectively. The corresponding gains of the first child in the nonteaching sector for LF and HF women are, respectively, \$382 and \$425. The gains in the same sector of a second child are \$85 and \$128 for LF and HF women, respectively. The "penalty" of the first child in teaching at the same age is \$98 for LF women and \$56 for HF women. A second child increases these penalties for LF and HF women to, respectively, \$1,089 and \$1,046.

My results further reveal that children decrease the utility gains from working and are consistent with most studies of female labor supply (Francesconi 2002; Sheran 2007; van der Klaauw 1996) and with those analyzing the labor market of teachers (Adda et al. 2017; Stinebrickner 2001a).[29] Particularly, the first child increases the penalties for teaching and nonteaching-employed women of age 24 by \$1,147 and \$468, respectively. A second child would increase the corresponding penalty for teaching workers to \$1,943 and decrease it for nonteaching workers to \$146.

To illustrate the implications of these estimates on teachers' career mobility patterns, I discuss below estimates of the two premia defined in Section 2. They are calculated by averaging the utility flows over individuals and are presented in terms of the average teaching wage in order to facilitate economic interpretation.

[27] Notice, however, that results are not directly comparable. This is because I estimate parameters for a sample of teachers and because I do not control for marital status. To the extent that the studies mentioned use data on women and jointly model labor supply and fertility decisions, they provide a simple check on the plausibility of my results.

[28] Francesconi (2002) and Kenneth (1984) found a similar result.

[29] Note, however, that Adda et al. (2017) classify occupations into three groups (routine, abstract, and manual) according to the tasks involved in each occupation. Because of the interaction with students, teaching is classified as an abstract occupation. The authors find that abstract jobs are less desirable when children are present. However, one must interpret this result with caution since primary and high school teachers are grouped together with university professors, and therefore conclusions made for abstract occupations are not representative of the single occupation of interest in this article.

Table 4 displays the "*children premia*," utility flows of employment transitions from the teaching sector associated with childbirth. The first rows of the three blocks (rows 1, 4, and 7 in the table) measure the gains of starting and enlarging families in teaching. An average teacher does not have nonpecuniary incentives to bear children and keep her current teaching job. The corresponding loss, if the first birth occurs within five years after certification, does not exceed 10% of the teaching wage, but becomes more important in later periods.[30] Instead, an average teacher finds it rewarding to drop out of the workforce to give birth, regardless of her current number of children. The gains of a first birth within five years after certification in the nonlabor market alternative (relative to teaching) lie between 83% and 98% of the average teaching wage.

TABLE 4
Children Premia
(In terms of average teaching wage)

	Number of years after certification											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
First Child												
T	-0.01	-0.03	-0.05	-0.08	-0.10	-0.14	-0.17	-0.21	-0.26	-0.30	-0.35	-0.40
NT	-0.72	-0.71	-0.70	-0.69	-0.67	-0.66	-0.65	-0.64	-0.62	-0.61	-0.59	-0.57
OWF	0.83	0.85	0.89	0.93	0.98	1.05	1.12	1.20	1.29	1.37	1.47	1.56
Second Child												
T	-0.13	-0.20	-0.29	-0.39	-0.51	-0.65	-0.80	-0.98	-1.17	-1.35	-1.56	-1.77
NT	-0.69	-0.67	-0.65	-0.62	-0.59	-0.55	-0.51	-0.46	-0.41	-0.36	-0.30	-0.24
OWF	0.86	0.90	0.96	1.03	1.11	1.21	1.32	1.45	1.59	1.71	1.87	2.02
Third Child												
T	-0.26	-0.38	-0.53	-0.71	-0.92	-1.16	-1.43	-1.74	-2.08	-2.39	-2.78	-3.14
NT	-0.58	-0.51	-0.41	-0.30	-0.17	-0.02	0.15	0.35	0.57	0.78	1.02	1.27
OWF	0.96	1.04	1.15	1.27	1.42	1.59	1.78	2.00	2.24	2.46	2.72	2.97

NOTE: T = Teaching; NT = Nonteaching; OWF = Out of the workforce.

The "*occupation premia*," the key measure in understanding reentry patterns associated with the presence of children, are presented in table 5. Provided a positive stock of children, former teachers employed in nonteaching jobs receive nonpecuniary gains upon reentry into teaching, whereas nonworking former teachers face penalties if they reenter teaching. For instance, the penalties associated with reentering teaching in period 8 for an average nonworking former teacher with one child are equivalent to 1.41 times the teaching wage. A reentry into teaching from the nonteaching sector in the same period and with the same number of children, on the other hand, yields gains equivalent to 42% of the average teaching wage.

[30] If the first birth occurs in period 12, the loss is equivalent to 40% of the teaching wage.

TABLE 5
Occupation Premia
(In terms of average teaching wage)

	Number of years after certification											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
T-NT												
1 child	0.70	0.68	0.65	0.61	0.57	0.53	0.48	0.42	0.36	0.30	0.23	0.15
2 children	0.56	0.47	0.36	0.23	0.08	-0.09	-0.29	-0.51	-0.76	-1.03	-1.33	-1.66
3 children	0.33	0.13	-0.11	-0.40	-0.74	-1.14	-1.58	-2.09	-2.65	-3.28	-3.97	-4.74
T-OWF												
1 child	-0.84	-0.89	-0.94	-1.01	-1.09	-1.18	-1.29	-1.41	-1.55	-1.70	-1.87	-2.06
2 children	-0.99	-1.11	-1.25	-1.42	-1.62	-1.86	-2.12	-2.42	-2.76	-3.14	-3.55	-4.01
3 children	-1.21	-1.42	-1.67	-1.98	-2.34	-2.74	-3.21	-3.73	-4.32	-4.97	-5.70	-6.49
NT-OWF												
1 children	-1.55	-1.56	-1.59	-1.62	-1.66	-1.71	-1.77	-1.84	-1.91	-2.00	-2.10	-2.21
2 children	-1.55	-1.58	-1.61	-1.65	-1.70	-1.76	-1.83	-1.91	-2.01	-2.11	-2.22	-2.35
3 children	-1.54	-1.55	-1.56	-1.57	-1.59	-1.61	-1.63	-1.65	-1.67	-1.70	-1.72	-1.75

NOTE.- T-NT = Teaching relative to nonteaching; T-OWF = Teaching relative to out of the workforce; NT-OWF = Nonteaching relative to out of the workforce.

My estimates are consistent with those found by Stinebrickner (2001a, 2001b) regarding the role of children in explaining teachers' quitting decisions: as families are created or enlarged, female teachers become less likely to be employed in teaching jobs and become more likely to drop out of the workforce altogether. The introduction of endogenous fertility in this model, however, opens up a new channel through which policies can affect retention outcomes. By allowing labor supply and fertility choices to be jointly determined, this study's estimates thus lead to different policy recommendations, as will be elaborated upon in Section 6. My estimates also allow us to understand how each choice affects the other not only within the early stages of a teacher's career, but also after a career interruption. Findings reveal that in late periods, after families have been created, the nonmarket alternative offers large nonpecuniary rewards in comparison to teaching, thus resulting in important penalties if nonworking teachers return to the profession. This outcome, combined with the gains of dropping out of the workforce due to childbirth, suggests that policy initiatives targeted to fertility choices will also generate changes in teachers' retention.

Key results of the interdependence of fertility behavior and labor force attachment to the teaching sector are depicted in table 6. Using births within two years after exit as a measure of fertility-related career interruptions, table 6 shows that teacher attrition is mostly a fertility-related event, especially for teachers exiting to the nonmarket option. Among leaving teachers, 66% give birth within two years after exit, and this percentage accounts for 81% and 50% among exiting teachers to the nonmarket alternative and the nonteaching sector, respectively. Furthermore, exiting teachers who leave for nonteaching and who drop out of the workforce differ in fertility behavior during their first teaching spell. Among exiting teachers who leave the workforce entirely, 18% accumulate children during

TABLE 6
Teacher Career Paths: Employment and Fertility

	Overall	Left to NT	Left OWF
First Teaching Spell			
Percent with children at exit time[a]	13.5	7.54	18.25
Percent Return[b]	1.29	17.22	3.27
Percent birth within 2 years after exit	66.17	50.41	80.61
Percent Return[b]	10.71	5.58	13.65
Percent no birth within 2 years after exit	33.83	49.59	19.39
Percent Return[b]	56.43	54.95	59.90
Career Interruption			
Percent birth during career break	33.15	15.48	54.66
Length career break	2.14	2.44	1.78
Return			
Percent[c]	23.71	29.37	19.20
Percent with children at reentry time[d]	36.97	19.90	57.76

[a] Exit time is the last year of the first teaching spell.
[b] Calculated as a proportion of leaving teachers associated with the previous row.
[c] Calculated as a proportion of leaving teachers.
[d] Reentry time is the first year a former teacher is observed in a teaching job after a spell out.

their first teaching spell. This percentage accounts for only 8% among exiting teachers who enroll in a nonteaching job.

Table 6 further illustrates that reentry into teaching is more likely to occur among former teachers who do not give birth during a spell out of teaching. The percentage of former teachers who return after a fertility-related career interruption is 11%, whereas 56% of former teachers who do not give birth within two years after exit return at some point. Since teachers exiting to the nonteaching sector accumulate fewer children during their careers than those who exit the workforce entirely, it is not surprising that the former are more likely to return than the latter (29% vs 19%, respectively). One point discussed in the literature is that after the child is old enough, the former teacher will return. Given the sample ends when most individuals are still fertile, it is not possible to account for the effect of children's age on a person's labor supply. However, this information is necessary to solve the value functions of forward-looking individuals who take into account that their young children will eventually become older. The estimates in this article are obtained using the assumption that school-age children have the same effect on nonpecuniary utility as younger children.

5.2 Model Fit

To formally examine the extent to which the model is able to capture changes in the behavior of women that take place after certification, the parameter estimates in table 3 were used to compute the simulated participation rates that correspond to the descriptive figure 1. Figure 2 shows that the model very accurately predicts the decreasing teaching participation rate that is observed over time for women. It also accurately predicts that this decrease takes place almost exclusively because of an increase in the proportion of women who are out of the workforce.

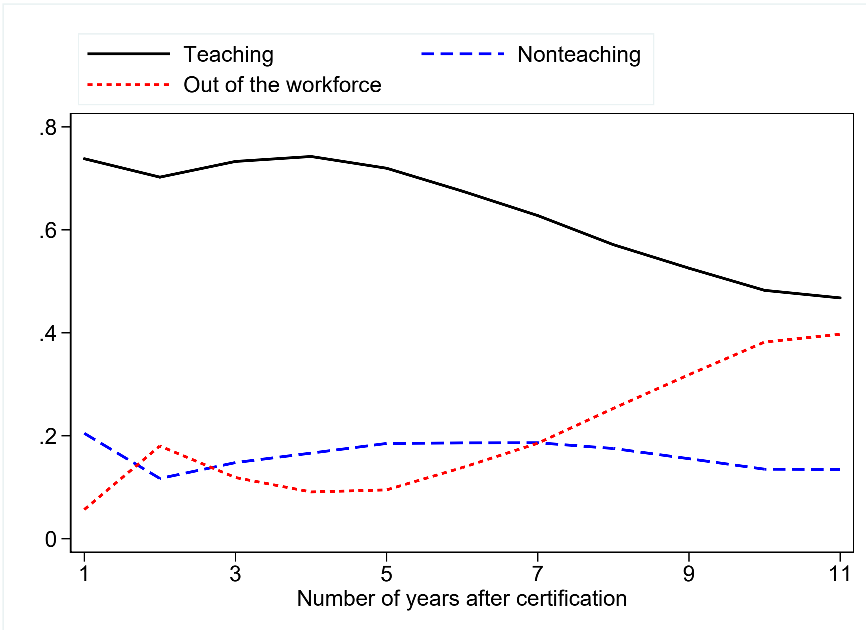


FIGURE 2
Simulated Participation Rates

As an additional measure of goodness of fit, table 7 presents the actual and predicted percentages of total person-years spent in each employment alternative, as well as the actual and predicted percentage of aggregate years in which a birth occurs. The dynamic model appears to fit the overall choices of the individuals in the sample very well. This is formally confirmed by chi-square goodness of fit test statistics which, at a 0.05 level of significance, do not lead to a rejection of the null hypothesis that the employment proportions generated by the model are the same as the employment proportions observed in the data. The model also predicts that the actual number of total person-years in which a birth occurs is the same, at the 0.05 percent level, as the predicted number of total person-years in which a birth occurs.

TABLE 7
Actual and predicted choices

	Actual	Predicted	Chi Square
Percent of total person-years spent:			1.68
Teaching	66.38	65.52	0.44
Nonteaching	16.51	16.63	0.03
Out of the Workforce	17.11	17.85	1.20
Giving Birth	10.33	9.43	3.27

NOTE.- $\chi_2 = \Sigma(n_p - n_a)^2/n_p$, n_p = number predicted and n_a = number actual. $\chi(2, 0.95) = 5.991$; $\chi(1, 0.95) = 3.841$.

6 POLICY SIMULATIONS

To illustrate how relaxing the assumption of exogeneous fertility leads to different policy recommendations, I perform two simulations. First, as in Stinebrickner (2001b), I raise the salary of all teachers by 20 percent. This uniform wage increase represents an increase in the pecuniary benefits of choosing a teaching job and is consistent with the current rigid wage structure in public schools. Second, I simulate reductions in the cost of childcare by increasing the utility of working in teaching jobs when children are present.[31] Specifically, I simulate subsidies of \$3,000 per year and \$4,000 per year by changing the parameter γ_{11} in table 3 from 113 to 3,113 and 4,113, respectively.[32] It is important to mention that the setting used by Stinebrickner (2001b) did not allow this author to simulate reductions in the cost of childcare. Consequentely, this author relies on his estimates of an increase in teaching pay to provide policy recommendations regarding childcare subsidies. This paper, on the other hand, empirically evaluates childcare policies with grounds on a setting that has been long recognized ideal while dealing with female labor decisions.

Rather than comparing the effects of these policies, the aim of these exercises is to illustrate the interdependence between family changes and employment decisions. In a setting where individuals simultaneously decide their fertility and labor force status, both policies have an impact on retention, measured as the percentage of aggregate years spent in teaching, and on fertility, measured as the average number of births per woman. From a policy point of view, however, we are not interested in teachers' fertility, and therefore the analysis below will focus on the main outcome of interest: retention. Changes in fertility will only be presented as they explain why retention has changed.

[31]This experiment is not based on what working women actually pay for childcare, since this information is only available for the last year of the survey. Instead, a childcare subsidy is given to all mothers working as teachers. This can be interpreted as either a financial payment or some nonpecuniary effort (such as increased work flexibility or a cost-free assistance during working hours for their children).

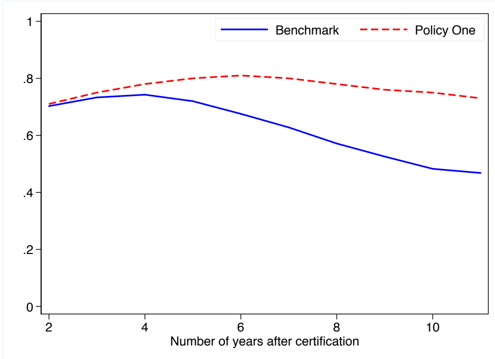
[32]Recall that an increase in γ_{11} reduces the disutility of working in teaching jobs and increases utility gains of teaching relative to the nonteaching sector. As Sheran (2007), I assume that the cost of childcare does not vary with age.

According to the US Bureau of the Census (2016), families with employed mothers spent, on average, \$44 per week (approximately \$2,200 per year), on childcare in 1986. Therefore, the changes in the cost of childcare that I simulate represent substantial reductions in the actual cost of childcare in the United States. Changes in the fiscal treatment of childcare costs over time allow us to further understand the magnitude of this study's second proposed policy. In 1954, a deduction for employment-related care expenses was established. The deduction became a credit in 1976, and in 1981 the limits were placed at $\$2,400$ per year for a family with one child and at $\$4,800$ per year for a family with two or more children.

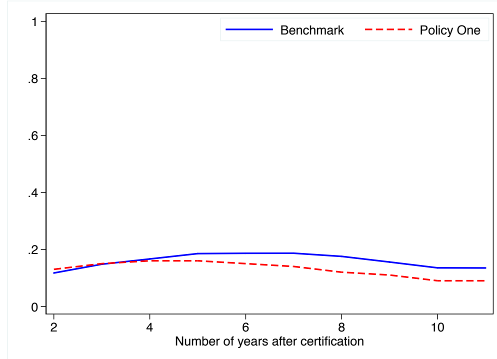
The effects of both policies on the two outcomes are reported in table 8. A 20% raise in teaching pay increases retention by 17%, a result mainly attributed to a larger decrease in the aggregate years spent out of the workforce rather than to a decline in the proportion of years spent in nonteaching (49% and 15%, respectively). Figure 3 illustrates that wage increases yield employment flows between teaching and out of the workforce throughout the sample period, and that the impact becomes more pronounced as the number of years since certification increases. Furthermore, higher teaching earnings decrease the average number of births by 50%. The negative effect on fertility is in line with previous empirical findings (Adda et al. 2017; Doepke et al. 2015; Galor and Weil 1996; Hondroyiannis 2010; Siegel 2017).

TABLE 8
Policy Experiments

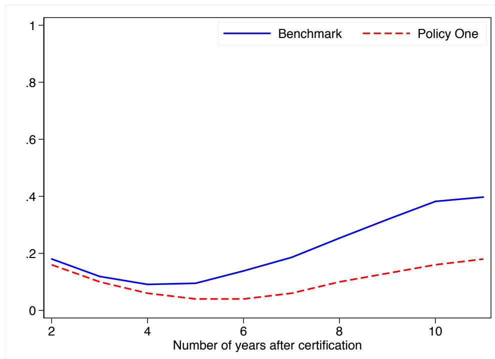
	Benchmark	**Increase Wages**	**Decrease childcare cost**	
			\$3,000/year	**\$4,000/year**
Percent of total person-years spent:				
Teaching	65.52	76.85	71.87	75.93
Nonteaching	16.63	14.07	14.86	13.90
Out of the Workforce	17.85	9.07	13.27	10.17
Average number births	0.96	0.48	1.36	1.29



(a) Teaching Participation Rate



(b) Nonteaching participation Rate



(c) Share out of the workforce

FIGURE 3
Policy One: A 20% Increase in Teaching Wages

The incorporation of a fertility channel in this article leads to different policy implications from Stinebrickner's (2001b) work, in which a framework where births occur stochastically is used to study teacher attrition patterns. First, the negative impact that wage increases have on fertility (which was not accounted for by Stinebrickner 2001b) reinforces the positive impact that wage increases have on employment, and thus leads to a more accurate impact on retention. Second, Stinebrickner's (2001b) estimates indicate that a 20% increase in teaching wages leads to a very large decrease in the proportion of individuals who choose nonteaching jobs, but has small impacts on the proportion of individuals who are out of the workforce. He relies on this result to conclude that childcare subsidies (which increase net teaching wages) would not be a cost-effective way to deal with teacher retention problems. By jointly modeling fertility and labor supply, however, I find that the increase in retention achieved with wage increases is mainly explained by a decrease in the proportion of nonworking women (see figure 3 and table 8). From a policy standpoint this is important because it demonstrates that only models that explicitly consider the endogeneity of fertility and labor supply are able to predict changes in fertility-related career interruptions, and thereby account for the potential benefits of policies targeted toward fertility choices.

In order to understand the forces behind the results in table 8, I present in table 9 the effects of regime changes on several choice probabilities along teachers' career paths. Wage increases diminish the percentage of teachers leaving the field by 30% and are more effective in retaining those who would otherwise exit the workforce entirely than in retaining those who would enroll in nonteaching jobs. Moreover, the negative effect on fertility is more concentrated after career interruption and among those who exit to the nonteaching sector.

TABLE 9
Policy Experiments: Exit and Return indicators

	Overall				Left to NT				Left to OWF			
	B	**Increase**	**Decrease childcare cost**		**B**	**Increase**	**Decrease childcare cost**		**B**	**Increase**	**Decrease childcare cost**	
		Wages	**$3,000/year**	**$4,000/year**		**Wages**	**$3,000/year**	**$4,000/year**		**Wages**	**$3,000/year**	**$4,000/year**
First Teaching Spell												
Left to	55.77	39.11	55.63	48.99	44.32	56.03	43.41	47.30	55.68	43.97	56.59	52.70
Lengh teaching spell	3.72	3.12	4.22	4.18	3.12	2.86	3.21	3.19	4.20	3.45	5.00	5.07
Perc with children at exit time[a]	13.50	13.07	84.64	84.78	7.54	6.20	81.24	82.05	18.25	21.82	87.25	87.23
Return[b]	1.29	3.88	21.77	25.23	17.22	30.91	37.44	42.73	3.27	5.92	17.35	18.80
Percent birth 2 years after exit[b]	66.17	31.92	37.48	34.70	50.41	20.48	20.24	19.20	80.61	48.65	53.90	53.48
Return[b]	10.71	10.28	32.90	39.21	5.58	6.46	61.92	66.10	13.65	12.63	22.52	27.51
Percent no birth 2 years after exit	33.83	68.08	62.52	65.30	49.59	79.52	79.76	80.80	19.39	51.35	46.10	46.52
Return	56.43	69.78	40.14	45.94	54.95	68.02	39.12	44.55	59.90	73.77	41.82	48.86
Career Interruption												
Perc birth during career break	33.15	10.36	33.01	31.27	15.48	3.95	28.66	26.07	54.66	22.18	38.79	39.47
Length career break	2.14	2.51	2.29	2.28	2.44	2.68	2.62	2.59	1.78	2.20	1.85	1.80
Return												
Percent[c]	23.71	46.91	32.47	36.67	29.37	54.25	42.64	47.42	19.20	37.54	24.67	27.02
Perc with children at reentry time [d]	36.97	13.86	100.00	100.00	19.90	7.48	100.00	100.00	57.76	25.62	100.00	100.00
Avg number of children at reentry time[d]	0.37	0.14	1.01	1.04	0.20	0.08	1.00	1.02	0.58	0.26	1.02	1.05

NOTE.- B = Benchmark.

[a] Exit time is the last year of the first teaching spell.

[b] Calculated as a proportion of leaving teachers associated with the previous row.

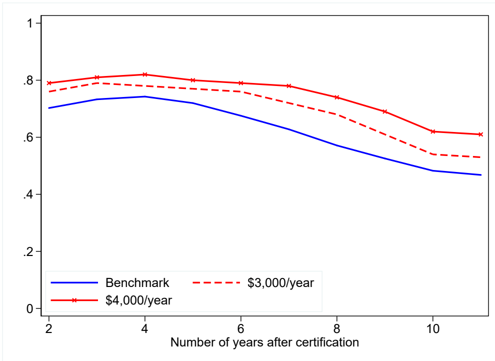
[c] Calculated as a proportion of leaving teachers.

[d] Return time is the first year she is observed in a teaching job after a career interruption.

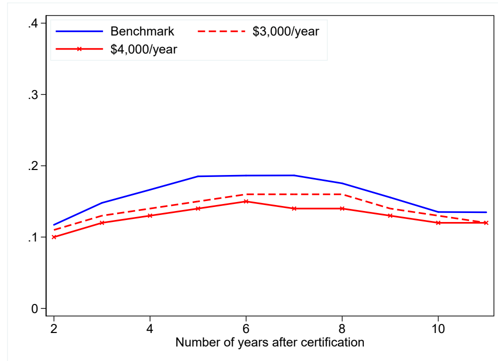
It is important to point out the implications of evaluating an increase in wages in a setting where the interdependence between employment and fertility decisions is taken into account. Fertility changes concentrated after a career interruption help explain the large effects on decreasing exits to the nonmarket alternative, and vice versa. Taking these two effects together, increasing wages reduces fertility-related career interruptions by 52%, which in turn changes the nature of the attrition problem in public schools. Unlike baseline results, leaving teachers respond to increasing wages by exiting more to the nonteaching sector than to the nonmarket alternative, resulting in exits out of teaching no longer associated with childbirth.

I next examine how changes in attrition patterns affect reentry behavior. Table 9 shows that higher teaching earnings increase the proportion of returners from 24% to 47% and that the effect is more pronounced among former teachers with exits not associated with childbirth. From the analysis of employment and fertility changes above, these results suggest that higher teaching pay increases the attractiveness of the teaching sector as teachers simultaneously decrease their fertility.

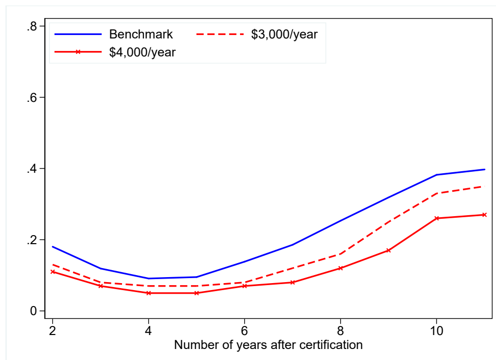
The $3,000 and $4,000 annual reductions in the cost of childcare increase retention by 10% and 16%, respectively. Figure 4 allows for a closer examination of the impact on yearly work patterns and reveals that the higher proportion of teachers employed in teaching jobs responds mainly to employment flows from the nonmarket option. The proportion of individuals employed in the nonteaching sector barely responds to reductions in the cost of childcare at early and late periods, whereas the share of individuals in the nonmarket alternative decreases throughout the sample period. Furthermore, reductions in the cost of childcare increase fertility. Yearly choice patterns reveal that the effect is higher at earlier periods and more pronounced in the teaching sector. My finding is in line with that of Adda et al. (2017), who show that women respond to a cash transfer at birth by having their children earlier.



(a) Teaching Participation Rate



(b) Nonteaching Participation Rate



(c) Share out of the workforce

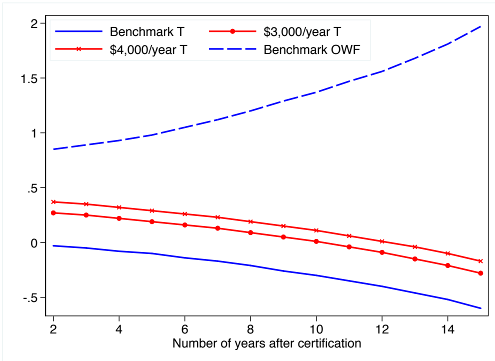
FIGURE 4
Policy Two: Reductions in the Cost of Childcare

Table 9 further indicates that reductions in the cost of childcare prolong the first teaching spell (particularly for those exiting the workforce entirely) and slightly decrease the percentage of exiting teachers. This result, combined with increases in fertility concentrated at early periods, suggests that reductions in the cost of childcare are an important initiative in increasing job attachment among beginner teachers, particularly among those who would otherwise have a fertility-related career interruption.

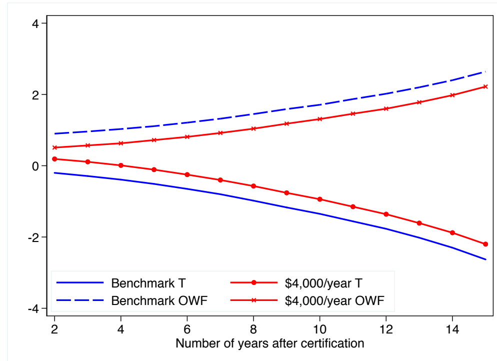
Changes on the *children premia* provide some insights into this result. Reductions in the cost of childcare increase the gains derived from children in the teaching sector, and therefore decrease utility flows associated with leaving teaching due to childbirth. Figure 5 illustrates the effect of reductions in the cost of childcare on *children premia*. The gap between the gains of exiting teaching entirely due to childbirth and those of staying in teaching and giving birth significantly shrinks. Indeed, Figures 5(b-c) illustrate that in early years, with a $4,000 reduction in the cost of childcare, the differences in gains associated with a second and third child are close to zero.[33] This result explains why starting teachers respond to reductions in

[33]In order to make figure 5 as readable as possible, changes in utility flows associated with leaving to nonteaching to give birth are not shown. Since baseline simulations produced negative values (see rows 2, 4,

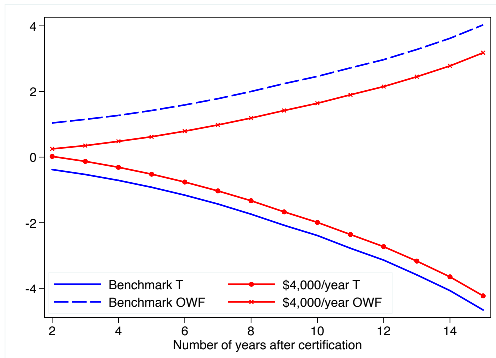
the cost of childcare by, on average, staying longer in teaching while simultaneously having more children.



(a) 1st Child Premium



(b) 2nd Child Premium



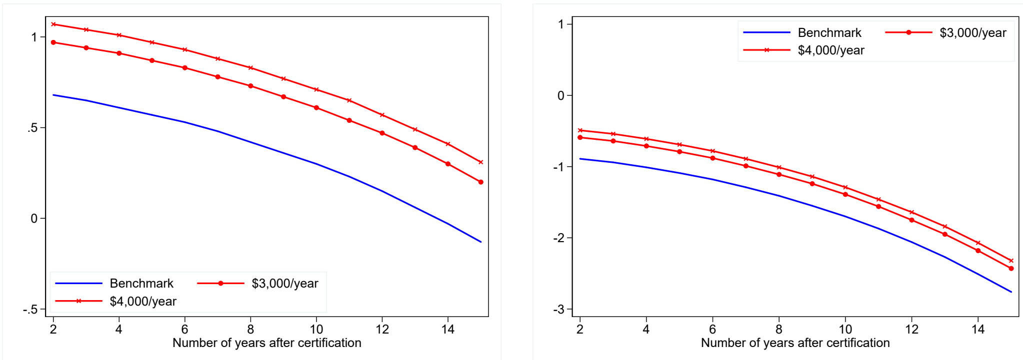
(c) 3rd Child Premium

FIGURE 5
Children Premia. Benchmark and reductions in the cost of childcare.

Table 9 allows further examination of how reductions in the cost of childcare, by simultaneously increasing fertility and the duration of the first teaching spell, affect reentry propensities. On the one hand, increases in fertility lead to increases in reentry rates. On the other hand, longer first teaching spells, which decrease the number of years in which a return to teaching could be observed, undermine propensities for reentry. The fact that the group that exhibits the greatest change in the first teaching spell, those who drop out of the workforce entirely, also exhibits the smallest increase in reentry rates illustrates this point. However, this smaller reentry effect that reductions in the cost of childcare have on the group with longer first teaching spells does not mean that this policy is ineffective in promoting reentry into teaching. Forecasts of the model beyond the actual data, which allow for an analysis of return propensities over a longer time period, is a field for further research.

and 6 in table 4) and reductions in the cost of childcare increase these penalties further, they do not play any role in explaining quitting behavior associated with fertility changes.

Changes in the *occupation premia*, shown in figure 6, provide further insight into reentry behavior. Reductions in the cost of childcare increase the gains associated with a return to teaching from the nonteaching sector and decrease the penalties associated with a return to teaching from the nonmarket option. Despite the increase in incentives associated with a return to teaching for nonworking women with children, results suggest that the large non-pecuniary rewards of the nonmarket alternative, combined with attrition rates concentrated at later periods, do not favor reentry into teaching.



(a) T-NT with one child

(b) T- OWF with one child

FIGURE 6
Occupation Premia. Benchmark and reductions in the cost of childcare.

Although the policies are not comparable, this study illustrates the mechanisms through which different fertility responses lead to increases in retention. On the one hand, increasing wages yield gains in retention through lower attrition and higher return rates as teachers simultaneously decrease their fertility. Reductions in the cost of childcare, on the other hand, increase fertility and the length of the first teaching spell as teachers simultaneously increase births and choose teaching jobs at early periods.

7 CONCLUSIONS

This article has been concerned with the construction and estimation of a structural dynamic model of career and fertility choices that a female teacher makes over her lifetime. In this model, the individual's finite-horizon optimization problem constitutes a dynamic programming problem that can be solved by backward induction. I estimate the model using the MSM with data from the NLS-72. Self-selection among the joint employment and fertility choices, based on expected future utility and unobserved heterogeneity in preferences for children, is shown to be an important element in fitting the data on the fertility and participation choices of female public school teachers. The proposed model is able to match accurately the decreasing trend in the teaching participation rate occurring after certification and to predict that this decrease takes place almost exclusively because of an increase in the proportion of women who are out of the workforce. The model also confirms that the total person-years spent in each employment alternative as well as the aggregate years in which a birth occurs are the same, at the 0.05 level, as the employment proportions observed in the data and the actual number of total person-years in which a birth occurs. The estimates were used to predict changes in teachers' patterns of employment and fertility stemming from a uniform 20% increase in teaching wages and to reductions in the cost of childcare.

Estimates indicate that attrition is a fertility-related event that responds to nonpecuniary gains lying between 83% and 98% of the average teaching wage if the exit occurs within five years after certification. Children increase the disutility of working in teaching jobs, and thus reentry into teaching is more likely to occur among former teachers who do not give birth after exit. A reentry into teaching for an average former teacher with one child yields nonpecuniary gains that lie between 15% and 42% of the teaching wage if reentry occurs from the nonteaching sector, and nonpecuniary penalties that lie between one and two times the teaching wage if reentry occurs from the nonmarket alternative.

Increasing wages improves retention through lower attrition and higher reentry rates as teachers simultaneously decrease their fertility. The largest attrition effect is observed among those who would otherwise drop out of the workforce, resulting in an average exiting teacher being more likely to leave teaching for the nonteaching sector than for the nonmarket alternative. Consequently, fertility-related career interruptions decrease by 52%. Former teachers respond to higher earnings by returning to teach in higher proportions. The positive effect on return rates is more pronounced among former teachers with exits not associated with childbirth.

This study's results shed light on new alternatives in dealing with retention problems. Unlike studies that take children exogenously or stochastically, this article finds that the gains in retention derived from wage increases respond to reductions in fertility-related career interruptions (and thus, in the proportion of nonworking women) rather than to a decline in the proportion of women employed in nonteaching jobs. This article, therefore, supports the view that policies that increase net teaching pay (such as childcare subsidies) would have important effects on retention.

Reductions in the cost of childcare of $3,000 and $4,000 increase retention by 10% and 16%, respectively. Both longer first teaching spells and higher reentry rates yield gains in retention. Fertility effects concentrated at early periods occur as teachers simultaneously choose teaching jobs resulting in longer first teaching spells. Large nonpecuniary benefits of the nonmarket alternative, however, seem to overcome the gains of returning to teaching when children are present, resulting in a greater impact on return rates among former teachers enrolled in nonteaching jobs rather than nonworking former teachers.

ABBREVIATIONS

NLS-72 - National Longitudinal Study of the High School Class of 1972.

MSM - Method of Simulated Moments.

APPENDIX

A Model Description

A.1 Dynamic Choice

I now describe in more detail the dynamic choices that individuals make. Section 2 presents the generic Bellman equation:

$$\begin{aligned} V_{jt}(\Omega_t) &= U_{jt}(\Omega_t) + \delta E_t V_{t+1}(\Omega_{t+1}|\Omega_t, d_{jt} = 1), \qquad t < A_0 + T \\ V_{j,A_0+T}(\Omega_{A_0+T}) &= U_{j,A_0+T}(\Omega_{A_0+T}), \end{aligned}$$

where j denotes the joint option of employment and fertility and Ω_t denotes the state space defined as $\Omega_t = (K_{t-1}, A_0, j_{t-1}, \omega_1\ I(e_{t-1} = 1), \omega_2\ I(n_{t-1} = 1))$.

As mentioned in section 2, there are 6 possible alternatives. The value functions of each of these alternatives are:[34]

$$V^{T,NB}(\Omega_t) = U_t^{T,NB} + \delta E_t V_{t+1}(\Omega_{t+1}), \tag{9}$$

$$V^{T,B}(\Omega_t) = U_t^{T,B} + \delta E_t V_{t+1}(\Omega^P_{t+1}), \tag{10}$$

$$V^{NT,NB}(\Omega_t) = U_t^{NT,NB} + \delta E_t V_{t+1}(\Omega_{t+1}), \tag{11}$$

$$V^{NT,B}(\Omega_t) = U_t^{NT,B} + \delta E_t V_{t+1}(\Omega^P_{t+1}), \tag{12}$$

$$V^{H,NB}(\Omega_t) = U_t^{H,NB} + \delta E_t V_{t+1}(\Omega_{t+1}), \tag{13}$$

$$V^{H,B}(\Omega_t) = U_t^{H,B} + \delta E_t V_{t+1}(\Omega^P_{t+1}). \tag{14}$$

The individual maximizes these conditional value functions in sequence. I denote these conditional value functions by indexing them with B for birth and NB if the woman does not give birth. I also index them with T for teaching, NT for nonteaching and H for out of the workforce. The subscript P indicates that the woman gives birth in t, so the number of children in the future state space is increased by one.

At the beginning of a period, women take as given their age, occupation, number of children, and their labor supply in the previous period. Women then decide to conceive a child or not. Women next decide how much to consume. Once fertility and consumption choices have been made, individuals observe shocks to labor supply, which consist of job offer arrivals. These shocks determine the labor status at the beginning of the next period.

I present below the employment-specific value functions. In all cases, the tilde (˜) in the

[34] Note that V_{1t}, V_{2t}, V_{3t}, V_{4t}, V_{5t}, V_{6t} in section 2 are referred, respectively, as $V^{T,NB}$, $V^{T,B}$, $V^{NT,NB}$, $V^{NT,B}$, $V^{H,NB}$, $V^{H,B}$, in this section.

future state space ($\tilde{\Omega}^P_{t+1}$ or $\tilde{\Omega}_{t+1}$) describes the future state space when the individual accepts the job offer from the alternative sector.

A.2 Value of teaching

I start with the value of teaching and conceiving a child. A woman working in a teaching job receives a job offer from the nonteaching sector. If she accepts it, she switches to the nonteaching sector. If she rejects it, she can either keep her current job for the next period or she can drop out of the workforce. The value is written as:

$$V^{T,B}(\Omega_t) = U_t^{T,B} + \delta E1max.$$

The first term consists of the current utility of consumption, leisure, and children, as described in equation 2. The second term is the future flow of utility, defined as:

$$E1max = E_t \max[VT(\Omega^P_{t+1}), VNT(\tilde{\Omega}^P_{t+1}), VH(\Omega^P_{t+1})].$$

The woman compares the future utility flows of keeping her current teaching job, accepting the job offer from the nonteaching sector, and dropping out of the workforce, and chooses the sector that provides the highest utility. The employment decision is made conditional on having an additional child. That is, the number of children in the future state space is increased by one.

The value of teaching and not giving birth is defined as:

$$V^{T,NB}(\Omega_t) = U_t^{T,NB} + \delta E2max,$$

where

$$E2max = E_t \max[VT(\Omega_{t+1}), VNT(\tilde{\Omega}_{t+1}), VH(\Omega_{t+1}))].$$

Since there is no birth in period t, the individual starts the next period with an updated state space Ω_{t+1}, where all the state variables but the number of children have been updated.

A.3 Value of nonteaching

When working in the nonteaching sector, a woman receives a job offer from the teaching sector. If she accepts the job offer, she becomes employed as a teacher. If she rejects it, she can either keep her current job or drop out of the workforce. The value of being in nonteaching and giving birth is:

$$V^{NT,B}(\Omega_t) = U_t^{NT,B} + \delta E3max.$$

The term $E3max$ is defined as:

$$E3max = E_t \max[VT(\tilde{\Omega}^P_{t+1}), VNT(\Omega^P_{t+1}), VH(\Omega^P_{t+1})].$$

The woman compares the future utility flows of keeping her current nonteaching job, accepting the job offer from the teaching sector, and dropping out of the workforce, then chooses the sector with the highest utility. The employment decision is made conditional on a future state space where the number of children is increased by one.

The value of nonteaching and not giving birth is:

$$V^{NT,NB}(\Omega_t) = U_t^{NT,NB} + \delta E4max,$$

where the term $E4max$ is defined as:

$$E4max = E_t \max[VT(\tilde{\Omega}_{t+1}), VNT(\Omega_{t+1}), VH(\Omega_{t+1})].$$

Since the woman chooses not to give birth in t, the future state space Ω_{t+1} is updated but the number of children remains the same.

A.4 Value of being out of the workforce

When a woman is out of the workforce, she receives a job offer from the teaching sector with probability ρ and a job offer from the nonteaching sector with probability $1 - \rho$. The value of being out of work and giving birth is modeled as :

$$V^{H,B}(\Omega_t) = U_t^{H,B} + \delta[\rho E5max + (1 - \rho)E6max],$$

where

$$E5max = E_t \max[VT(\tilde{\Omega}^P_{t+1}), VH(\Omega^P_{t+1})],$$

and

$$E6max = E_t \max[VNT(\tilde{\Omega}^P_{t+1}), VH(\Omega^P_{t+1})].$$

The woman compares the utility flows of remaining out of the workforce and accepting the job offer from the corresponding sector. As in $V^{T,B}$ and $V^{NT,B}$, the employment decision is made conditional on a future state space where the number of children is increased by one.

The value of being out of the workforce and not giving birth is modeled as :

$$V^{H,NB}(\Omega_t) = U_t^{H,NB} + \delta[\rho E7max + (1 - \rho)E8max],$$

where

$$E7max = E_t \max[VT(\tilde{\Omega}_{t+1}), VH(\Omega_{t+1})],$$

and

$$E8max = E_t \max[VNT(\tilde{\Omega}_{t+1}), VH(\Omega_{t+1})].$$

Since there is no birth occurs in t, all variables but the number of children in the future state space are updated.

A.5 Fertility decision

The decision of whether to give birth or not is taken as:

$$V^T(\Omega_t) = \max[V^{T,B}(\Omega_t), V^{T,NB}(\Omega_t)],$$

$$V^{NT}(\Omega_t) = \max[V^{NT,B}(\Omega_t), V^{NT,NB}(\Omega_t)],$$

$$V^H(\Omega_t) = \max[V^{H,B}(\Omega_t), V^{H,NB}(\Omega_t)].$$

The decision to give birth, noted by k_t in section 2, is the arg max of the expressions above.

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