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The Personal Tax Exemption and Married Women's Birth Spacing in the United States

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In this article, several specifications of the piecewise-linear segment hazard rate model with exponential distribution are estimated to investigate the effect of the personal tax exemption (PTE) on married women's birth spacing. Using a sample collected from the Panel Study of Income Dynamics, the estimation results from the hazard rate model confirm that married couples with a high PTE tend to shorten the length of the second and third birth intervals. Furthermore, the hazard rate increases until four years after the preceding birth and then decreases in the case of the third birth, although this is not so for the second birth.

Keywords: *birth spacing; fertility; hazard rate model; income tax; personal tax exemption*

1. Introduction

Since both the quantity of children born and the birth interval can influence the growth of the population, fluctuations in the fertility rate can be decomposed into changes in the number of children per family and the spacing between their births. The average family size in the United States has fallen since the end of the Second World War. A change in fertility behavior has both reshaped the generational structure of the population and decreased the momentum of population growth, further triggering new social concerns in such areas as employment, retirement, education, and health services. The stable two-child norm implies that much of the variation in the fertility rate within the United States now occurs as a result of the timing of having children, rather than the number of children. Hence, the timing of births can be at least as significant as parity for understanding variations in fertility behavior.

Variations in the timing of human reproduction may be the result of biological or behavioral differences across the population. Differences in fecundity because of age or heredity are unquestionably very important determinants in the timing of births; this issue, however, goes beyond the paradigm of economics. Given the assumption that people can control their fertility behavior absolutely, the economic theory of household decisions, which explores the link between reproductive behavior and constrained utility maximization, is increasingly being used to explain the differences in human fertility behavior.

Most of the previous research and discussion in respect of the timing of births has concentrated primarily on the significant influence of social and biological factors, including age, parity, child mortality, cohorts, age at marriage, race, the gender composition of children in the family, the total fertility rate, education and the length of the preceding birth interval (e.g., Happel, Hill, and Low 1984; Teachman and Schollaert 1989; Maxwell 1991). Additional studies, using international data, have devoted themselves to examining the issue of the determinants of fertility timing (e.g., Newman and McCulloch 1984; Trussell et al. 1985; Heckman, Hotz, and Walker 1985; Chang 1988). There has, therefore, been insufficient effort on the part of researchers to explore the influence of economic factors on the birth interval, such as the opportunity cost of raising children and family resources (e.g., Happel, Hill, and Low 1984).

The personal tax exemption (PTE) in the United States tax system is a subsidy for families with children that effectively lowers the direct cost of raising children.[1] According to Georgellis and Wall's (1992) theoretical "model of fertility choice," it is found that the existence of the PTE creates an economic incentive, ceteris paribus, for a family to have more children.[2] This hypothesis has been supported by many existing empirical studies (e.g., Whittington, Alm, and Peters 1990; Whittington 1992, 1993; Georgellis and Wall 1992; Gohmann and Ohsfeldt 1994; Huang 2002). In addition, some studies further support the hypothesis that the PTE provides a clear incentive for a couple to advance the timing of births (e.g., Huang 1998a; Dickert-Conlin and Chandra 1999).[3] However, as yet there has been no discussion on the influence of the PTE on birth spacing decisions.

The main thrust of the present study is directed at determining how the federal-income-tax PTE affects the time interval between births. After constructing a simple theoretical model and using several specifications of the piecewise-linear segment hazard rate model and Panel Study of Income Dynamics (PSID) data, the main findings confirm that married couples with a high PTE tend to shorten the length of the second and third birth intervals.

The remainder of this article is organized as follows. Section 2 provides a review of the literature on PTE–fertility relations and is followed by a simple theoretical model describing the relationship between the PTE and birth intervals in Section 3. Section 4 provides an introduction to the piecewise-linear segment hazard rate model and a description of the data and variables. The empirical results are discussed in Section 5. Finally, the conclusions are summarized in Section 6.

2. A Review of the Literature on PTE–Fertility Relations

Ever since Becker (1960) constructed an economic theory to analyze human fertility behavior, an abundance of empirical evidence has been assembled to explore the relationship between economic and demographic factors and the demand for children (e.g., Cain and Weininger 1973; Blau and Robins 1989; Mocan 1990).[4]

The first empirical study to investigate the PTE–fertility relation was a time-series analysis conducted by Whittington, Alm, and Peters (1990). The central finding of their article was that the real value PTE has a positive and statistically significant effect on the national birthrate.[5] In addition, Georgellis and Wall (1992) added a quadratic variable for the real-value PTE into the fertility regression models and obtained the diminishing marginal influence of an increase in the federal-income-tax PTE on the fertility rate.[6] Moreover, Gohmann and Ohsfeldt (1994) extended the time-series data applied in Whittington, Alm, and Peters (1990) to the year 1988 and added an explanatory variable for the availability of abortion to the regression models. Their empirical results further support the conclusion that the PTE does have a positive effect on the fertility rate.

A number of panel studies have indeed been undertaken to test the same hypothesis. Whittington (1992) employed the PSID data to show that an increase in a specific family's real-value PTE increases the likelihood that they will have an additional child. However, Whittington (1993) did not support the hypothesis that state-income-tax PTE could positively affect fertility behavior. Recently, Huang (2002) used Taiwan's county-level panel data to suggest that the value of PTE has a positive and statistically significant effect on the general fertility rate in Taiwan. Nevertheless, the cost to the government to induce a single additional birth would be very high.

The value of the PTE can affect the decision not only of whether to have children but also when to have them. Huang (1998a) used a sample from the PSID and an empirical model to propose that families with a high real-value PTE are more likely to reschedule the timing of a birth from the first two months of the year to the last two months of the previous year. In addition, Dickert-Conlin and Chandra (1999) showed that the tax benefit has a positive effect on people's propensity to give birth in the last week of December, rather than the first week of January.

Although the positive role played by the PTE in fertility behavior has been confirmed by many studies, how the PTE affects the birth interval has not yet been investigated. In what follows, a simple theoretical model will first be constructed, and later a hazard model will be used to examine the influence of the PTE on married women's birth intervals.

3. A Simple Model of PTE and Birth Intervals Relations

It is difficult to use economic theory to explore the influence of the PTE on birth intervals based on the existing approach to the economic modeling of childbirth timing that consists of static lifecycle models constructed by Happel, Hill, and Low (1984) and dynamic fertility models established by Cigno and Ermisch (1989).[7] However, the properties of the PTE as well as the child benefit, defined as a lump-sum transfer per child paid by the government in Cigno and Ermisch (1989), are quite different because the PTE differs for families with different marginal tax rates. The value of the PTE for a specific family has been defined, in Whittington, Alm, and Peters (1990), as the product of the statutory value PTE (denoted as E) and the couple's marginal tax rate (denoted as tr):

$$PTE = E \times tr. \tag{1}$$

This value represents the total reduction (with the associated tax benefit) in the cost of raising a child.[8] It varies across families as a result of differing marginal tax rates within different families. Hence, the PTE is not a lump-sum subsidy related to the cost of having children, and using the theoretical model that appears in Cigno and Ermisch (1989) may be inappropriate.

This study constructs a simple theoretical model in the spirit of Model C in Razin (1980) to illustrate the relationship between the PTE and the length of the interval between births. A household welfare function is presented as a function of the parents' consumption, the number of children, and the quality of children defined as the total amount of time that the mother spends caring for her children.[9] This total amount of time equals the product of the time interval between births and the proportion of time during the childrearing period that the mother works at home, and leisure is treated as an exogenous variable. In addition, it is assumed that the age of the mother at the last birth will be equal to her expected latest fertile age and that there is no pre-birth working period. Moreover, to make the birth interval a choice variable, it has to be assumed that the mother works at home full-time during the entire childrearing period.

The household's problem is to choose optimal choice variables, including consumption, the number of children and the birth intervals, subject to the parents' lifetime budget constraint, to maximize its welfare function. Lifetime family earnings include the husband's earnings, other sources of family income, and the wife's earnings during the post-childrearing period. The other constraint is that the difference between the age of the mother at the final birth and her age at the first birth equals the total duration of previous $(N-1)$ births.

First, the utility maximization problem is as follows:

$$\begin{gathered} \underset{G,B,S}{Max}\, U(G,B,S) \\ \text{s.t. } G+(C-E\times tr)\times B=(1-tr)\times I^{*}+I_0 \\ S\times(B-1)=A \\ I^{*}=I_m+W_L\times(a_r-a_b-S) \\ A=a_b-a_m \end{gathered} \tag{2}$$

In equation (2), G is the parents' consumption, B is the number of children, S is the length of the interval between births,[10] C is the direct cost per child, E is the statutory PTE, tr is the marginal tax rate of the parents, I^* is the family taxable income, I_m is the husband's lifetime earnings, W_L is the wife's earnings in the post-childrearing period, I_0 represents family income from other sources, a_b is the mother's age at the last birth, which is equal to the mother's expected latest fertile age, a_r is the mother's age at retirement, a_m is the mother's age at the first birth, and G, B, and S are endogenous.

The first constraint implies that the total parents' lifetime expenditure on consumption and childrearing is equal to their total lifetime earnings net of taxes. The real value of PTE enters into the first constraint, acting as a deduction of childrearing costs. In addition, the second constraint means that the length of the interval between the first and the last births is equal to the length of the birth interval times $(B-1)$ children.

After solving the utility-maximization problem by choosing G, B, and S, the comparative static results indicate that, under certain conditions,[11] ceteris paribus, an increase in the PTE caused by an increase in the marginal tax rate decreases the wife's earnings net of taxes as well as the opportunity cost of the wife's time spent caring for children, and this encourages people to have more children. Based on the second constraint in equation (2), the birth interval decreases as the number of children increases to keep the total fertile period constant. Therefore, this study hypothesizes that an increase in the PTE might shorten the intervals between the births of married couples.

4. Empirical Model and Variables

4.1 The Piecewise Linear Segment Hazard Rate Model

The hazard rate model provides an effective technique for analyzing situations involving uncertainty. Because human fertility behavior is a stochastic biological process involving sequential conception events, the application of the hazard rate model to human fertility behavior is appropriate and is based on the length of time between two successive births.[12] Suppose that the random variable T is the waiting time for conception, and that it has a continuous probability distribution $f(t)$. Then the cumulative probability function $F(t)$ is defined as:

$$F(t) = \int_0^t f(x)dx = \text{Prob}(T \leq t) \tag{3}$$

In equation (3), the F function represents the probability that the waiting time to conception is no longer than t. Furthermore, the survival function $K(t)$, equal to $1 - F(t)$, is the probability that the length of time to conception is at least t. Hence, the hazard rate of conception at time t, $h(t)$, is the conditional probability of waiting time 0 to t to conception, given the length of time that a wife has been waiting to conceive.

$$h(t) = \frac{f(t)}{K(t)} = \frac{f(t)}{1 - F(t)} \tag{4}$$

The hazard rate can be either duration independent or duration dependent.[13] Within the scope of fertility behavior, the common feature of duration dependence, in conception or fertility, is that the hazard rate increases over time to a maximal level and then decreases over time at a slow rate. The more appropriate distribution of the hazard rate of fertility is, therefore, represented in the piecewise-linear segment hazard rate model (e.g., Newman and McCulloch 1984; Chang 1988). The piecewise-linear segment hazard rate model is given by:

$$h(t) = \exp[\beta_0 + \sum_{i=1}^{n} \beta_i X_i + (\alpha_1 + \alpha_2 y)t], \tag{5}$$

where t is the waiting time to conception, X represents the covariate in the hazard rate function, and y is a dummy variable indicating that the duration $\geq$ four years.[14] The dummy variable y is also used to explore the change in duration dependence. If the magnitude of the positive α_1 is less than that of the negative α_2, it is concluded that the hazard rate first increases, then decreases after $t >$ four years (see Chang 1988).[15] From equation (5), the hazard function becomes:

$$\ln h(t) = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + (\alpha_1 + \alpha_2 y) \times t \tag{6}$$

Let $K(t) = \exp[-\int_0^t h(u)du)]$ be the corresponding survivor function. The likelihood of observing that the period $t_0 = 0$ to t_1 ends in having a conception ($\sigma = 1$) or censoring ($\sigma = 0$) is $K(t_1)h(t_1)^{\sigma}$ The log-likelihood function for N observations, each observed from t_0, to t_1, is then as follows:

$$\ln L = \sum_{j=1}^{N} \ln K(t_{1,j}) + \sigma_j \ln h(t_{1,j}) \tag{7}$$

β_i will be estimated by the maximum likelihood estimation method. After taking the first derivative of equation (6) with respect to X_k, we can obtain:

$$\frac{\partial \ln h(t)}{\partial x_k} = \beta_k \tag{8}$$

Equation (8) implies that a change in X_k, by one unit, will change the hazard rate at the rate β_k. It is worth noting that the factors that are positively related to the hazard rate will be negatively associated with the length of duration to conception. In addition, the hypothesis that the hazard rate of conception increases monotonically over time initially, and then decreasing at a lower rate as the duration increases, is also tested. Therefore, the following null hypotheses are tested in this research:

$$\begin{cases} H_0 : \beta_{PTE} > 0 \\ H_1 : otherwise \end{cases} \begin{cases} H_0 : \alpha_1 > 0 \\ H_1 : otherwise \end{cases} \begin{cases} H_0 : \alpha_2 < 0 \\ H_1 : otherwise \end{cases} \tag{9}$$

4.2 Data and Variables

The data used in this study were collected from the PSID, which included information regarding individuals' birth and marriage histories in individual data files in 1992. The PSID, therefore, provides sufficient information concerning marriage and birth history to examine a married couple's decisions regarding the birth spacing of second and third births. This research combines the individual file and family files from 1980 to 1991, treats marital status as exogenous, selects the sample from the Survey Research Center sample, and limits married women whose first or only marriage was valid when they had their second or third child or by the final interview date.[16]

It is assumed that a wife is at risk of conceiving the N-th birth starting from two months after the previous birth until either she reaches the age of 50, the N-th birth occurs, or her experience is censored by the end of 1991. Because it is very difficult to obtain the time interval for the first conception,[17] the case of the first child is ignored. Any individuals with missing data are eliminated from the sample.

In fact, some independent variables are time-varying and some are time-invariant. The time interval between births is, thus, divided into many small periods to make all time-varying independent variables constant during a specific period (year), and as a result, some individuals have more than one record. As a result, there are 1,264 observations for 431 individuals in the case of the second birth interval and 2,373 observations for 462 individuals in the case of the third birth.[18]

The definition of the birth duration is very important in this study. In general, there are three segments contained in the interval between two successive conceptions: the approximate nine months' duration of pregnancy, the duration of temporary sterility that may last two months,[19] and the duration of fecundity before the next conception. Hence, the interval between two successive births in this research is defined as the length of the interval between two months after the date of the preceding birth and nine months before the date of the next one.

The primary explanatory variable PTE is defined as the statutory PTE multiplied by the marginal tax rate of each married couple in Whittington, Alm, and Peters (1990). The marginal tax rate of each married couple is affected by the wife's wage, which is expected to have a negative effect on the hazard rate of fertility. To separate the negative effect of the wife's wage on the timing of births from the influence of the PTE, this study estimates a new marginal tax rate, excluding the wife's annual earnings, to calculate a new PTE.[20] As discussed in Section 2, the PTE has a negative influence on the birth interval (i.e., it has a positive relationship with the hazard rate).

Several other economic explanatory variables are included in the model as well. According to the aforementioned theoretical model, household income is positively associated with the time interval between births.[21] The women's employment status or earnings have a negative effect on the hazard rate for conception, because women employed in the market have a higher opportunity cost of childrearing than those who are not employed. Moreover, Happel, Hill, and Low (1984) indicated that women with highly skilled white-collar or blue-collar occupations tend to have their first baby earlier in their marriages because of their rapid skill deterioration. Hence, it is expected that the estimated coefficient of a highly skilled dummy variable is higher than that of a low-skilled occupation dummy variable for women in the hazard rate model.

Some aggregate-level factors are also included in the empirical model. Aggregate fertility rates, in general, reveal national preferences in birth and childbearing. Higher national fertility rates may also increase women's hazard rates in regard to conception. In addition, the aggregate unemployment rates of females, serving as a period control for reduced women's wages, will have a positive influence on the length of the birth interval. According to Cigno's articles, higher interest rates cause women to postpone the timing of birth because of the lower cost of raising children in the next time period.

The length of the preceding interval has been proven to be significantly positively associated with subsequent intervals (e.g., Rodríguez et al. 1984; Chang 1988). Contradictory results, however, have been found by Heckman, Hotz, and Walker (1985). In the present study, a variable for the length of the preceding birth interval is included to investigate this controversy and also to control part of the heterogeneity pointed out by Chang (1988).

Cohort differences may result from the differences in both the levels of, and the relationships between, individual and aggregate influences. It is expected that women in the later cohort are much more likely to use more effective forms of birth control and are less likely to have an unwanted or mistimed birth and thus have a lower fertility rate than those in the earlier cohort. In addition, the woman's current age is also included in the hazard rate model; because the remaining reproductive period becomes shorter as women get older, they may increase their fertility tempo to achieve their desired number of births. By contrast, the natural fecundity of a woman decreases as her age increases. Hence, the net age effect on the duration of the birth interval is ambiguous.

Furthermore, Newman and McCulloch (1984) suggested that wives with high education levels tend to have their children at shorter intervals to minimize the total amount of time and goods used over the childrearing period. In addition, Kravdal (1994) and Trussell and Bloom (1983) concluded that

Table 1
Variables and Descriptive Statistics for Second and Third Births

Variables	Description	*M* (*SD*) Second	Third	Sign
PTE[a]	Real value of personal tax exemption in 1982-1984 dollars	301.16 (128.57)	293.75 (124.27)	+
New PTE[a]	Estimated RPTE (using estimated marginal tax rate excluding the wife's earnings)	238.43 (114.94)	247.48 (114.41)	+
Income[a]	Real total value of husband's annual earnings and family transfer income	233.15 (160.24)	253.46 (192.62)	–
Working status	Wife's working status: 1 = *wife employed*, 0 = *otherwise*	0.65 (0.48)	0.65 (0.48)	–
High—white	Wife's occupation: 1 = *high-skilled white collar*, 0 = *otherwise*.	0.63 (0.48)	0.62 (0.48)	
High—blue	Wife's occupation: 1 = *high-skilled blue collar*, 0 = *otherwise*.	0.05 (0.21)	0.03 (0.18)	
Age	Wife's age	27.89 (4.67)	31.30 (5.19)	?
Cohort—1940	1 = *Wife born in 1940s*, 0 = otherwise	0.03 (0.17)	0.11 (0.31)	
Cohort—1950	1 = *Wife born in 1950s*, 0 = *otherwise*	0.52 (0.50)	0.65 (0.48)	
Preceding interval	The length of waiting time to conception of the birth in months	40.44 (34.13)	32.97 (48.28)	?
White	Family race: 1 = *White husband*, 0 = *otherwise*	0.96 (0.20)	0.94 (0.24)	
City	1 = *resident in city with population > 100,000*, 0 = *otherwise*	0.43 (0.49)	0.38 (0.49)	

Table 1 (continued)

Variables	Description	M (SD) Second	Third	Sign
North	1 = *family lives in northeastern U.S., 0 = otherwise*	0.21 (0.41)	0.21 (0.41)	
South	1 = *family lives in southern U.S., 0 = otherwise*	0.27 (0.44)	0.28 (0.45)	
West	1 = *family lives in western U.S., 0 = otherwise*	0.19 (0.39)	0.17 (0.38)	
Interest[a]	Interest rate	9.28 (2.51)	8.80 (2.15)	–
Fertility[a]	Fertility rate	67.37 (1.83)	67.46 (1.96)	+
Unemployment[a]	Female unemployment rate	6.94 (1.35)	6.69 (1.29)	–
Education	1 = *Wife's years of education > 12, 0 = otherwise*	0.63 (0.48)	0.55 (0.50)	+
Year	Year	86.48 (3.21)	87.25 (2.96)	
Duration	The length of duration	2.57 (1.90)	4.17 (2.79)	

NOTE: $N = 431$ for the second birth and $N = 462$ for the third; observations totaled 1,264 for the second birth and 2,373 for the third.
a. Variables are one-year lagged.

women with high education levels also attempt to delay their first birth, and therefore their hazard rate for the second conception might be higher in order that they may have their desired number of children by a certain age. Therefore, it is expected that the female's educational level will be positively associated with the hazard rate for conception.

The duration-dependence variables, α_1 and α_2, and several demographic factors, such as race, region, and the population of the city, are also included to control for heterogeneity across individuals. As people are not expected to predict all economic variables for the current year perfectly when they make decisions, all economic variables included in the empirical models are lagged one year behind the year of conception and expressed in terms of 1982-1984 dollars to control for inflation. Descriptive statistics of the variables included in the models are provided in Table 1. It is worth noting that, because Table 1 provides means and standard deviations pertaining to the observations of the exposure intervals rather than to the average statistics for the individuals themselves, it is difficult to interpret these statistics.

5. Estimation Results

Several specifications adopted in this study are described as follows: Models 1 and 2 differ, as Model 2 includes a time trend variable and Model 1 does not. The wife's working-status variable is replaced by two dummy variables in Model 3. Model 4 replicates Model 1, but without macro-level variables. Finally, to investigate the different effects of independent variables on all families and on only White families, Model 5 replicates Model 1, but it is for White families only.[22]

5.1. The Second Birth

Table 2 shows maximum likelihood estimation results of several specifications of the piecewise-linear segment hazard rate models with exponential distribution for the spacing of the second birth.[23] The coefficient of the new PTE is statistically significant. In Models 1, 2, and 5 in Table 2, the percentage impact of the PTE on the hazard rate of the second conception is 0.1. For example, in Model 1, families with one more dollar of the PTE have a shorter birth interval and a higher hazard rate of the second conception than those of other families, by 0.1 percent. In other words, if a couple plans to conceive the second child four years (1,460 days) after the first child, who is two months old, a one-dollar increase in the PTE will encourage the couple to reduce the duration by 1.46 days. Moreover, the empirical results do not prove that the PTE has different influences on the hazard rate of the second conception for the entire sample and for the White subsample.

Regarding the duration-dependence, almost all specifications in Table 2 show that the sign of α_1 is significantly positive but significantly negative for α_2. Because the magnitude of α_1 is slightly greater than that of α_2, the hypothesis that the hazard rate for the second conception increases initially, and then decreases, cannot be accepted.

In Table 2, all coefficients of family income are significantly negative in all specifications. In most specifications, the influence of the wife's employment status is not significant. Nevertheless, Model 3 proves that women with high-skilled occupations will have a higher hazard rate in conceiving a second child and will have a shorter second birth interval. This result is consistent with the theoretical conclusions in Happel, Hill, and Low (1984). Furthermore, it is suggested that short previous birth intervals are associated with a high probability of conception in subsequent births. This conclusion is consistent with the findings of Rodríguez et al. (1984) and Cheng

Table 2
Estimation Results for Second Births

Covariates	Model 1	Model 2	Model 3	Model 4	Model 5
New PTE	0.001* (6×10^{-4})	0.001* (6×10^{-4})	0.001 (7×10^{-4})	8×10^{-4} (6×10^{-4})	0.001* (6×10^{-4})
Income	-1×10^{-5}** (4.7×10^{-6})	-1×10^{-5}** (4.6×10^{-6})	-9.8×10^{-6}** (4.6×10^{-6})	-9×10^{-6}** (4.8×10^{-6})	-1×10^{-5}** (4.7×10^{-6})
Working status	–0.118 (0.124)	–0.134 (0.124)		–0.107 (0.125)	–0.123 (0.126)
High—white			0.294** (0.135)		
High—blue			0.036 (0.303)		
Age	–0.008 (0.024)	–0.02 (0.025)	–0.012 (0.023)	–0.03 (0.021)	–0.007 (0.024)
Cohort—1940	–0.616 (0.687)	–0.45 (0.704)	–0.609 (0.678)	–0.244 (0.657)	–0.623 (0.687)
Cohort—1950	0.143 (0.185)	0.231 (0.200)	0.136 (0.184)	0.319** (0.144)	0.127 (0.189)
Preceding interval	–0.007*** (0.002)	–0.007*** (0.002)	–0.007*** (0.002)	–0.007*** (0.002)	–0.007*** (0.002)
White	0.208 (0.31)	0.218 (0.303)	0.169 (0.315)	0.286 (0.29)	
City	0.249* (0.129)	0.253** (0.128)	0.251* (0.129)	0.268** (0.129)	0.245* (0.13)
North	–0.002 (0.151)	–0.016 (0.151)	–0.035 (0.152)	–0.005 (0.152)	0.012 (0.154)
South	–0.255 (0.155)	–0.261* (0.156)	–0.285* (0.157)	–0.246 (0.156)	–0.25 (0.157)
West	–0.166 (0.169)	–0.162 (0.169)	–0.185 (0.167)	–0.16 (0.17)	–0.188 (0.174)
Interest	0.052 (0.032)	0.108** (0.048)	0.052 (0.032)		0.06* (0.033)
Fertility	–0.13*** (0.048)	–0.172*** (0.054)	–0.132*** (0.048)		–0.142*** (0.05)
Unemployment	–0.045 (0.069)	0.045 (0.09)	–0.052 (0.069)		–0.071 (0.071)
Education	0.062 (0.134)	0.065 (0.134)	0.007 (0.138)	0.065 (0.133)	0.076 (0.138)
Year		0.099 (0.066)			
Constant	4.243 (3.257)	–2.39 (5.57)	4.306 (3.274)	–3.911*** (0.54)	5.304 (3.374)
Duration dependence					
α_1	0.454*** (0.059)	0.439*** (0.06)	0.463*** (0.059)	0.459*** (0.058)	0.446*** (0.06)
α_2	–0.41*** (0.052)	–0.401*** (0.052)	–0.411*** (0.052)	–0.42*** (0.052)	–0.403*** (0.053)
No. of subjects	431	431	431	431	411
No. of failures	298	298	298	298	287
Log likelihood	–843.465	–842.285	–841.344	–847.434	–811.076

Note: Numbers in parentheses are standard errors. Standard errors adjusted for clustering on the subject-id variable. Asterisks indicate significance at the (*) 10-percent, (**) 5-percent, and (***) 1-percent levels, respectively, for the two-tailed test.

(1988). In addition, the fertility rate has a significantly negative influence on the hazard rate for the second birth. This result is in contrast to the conclusions in Maxwell (1991) because Maxwell's study focuses on the first birth.

This study cannot support the hypothesis that the female's educational level is negatively associated with the second birth interval. Finally, the influences of the wife's age, the interest rate, the female unemployment rate, and the cohort variable are all insignificant.

5.2. The Third Birth

Table 3 provides estimation results for the case of the third birth. The significantly positive effect of the PTE on the hazard rate of the third birth is even higher, with a percentage influence of magnitude 0.2 on the hazard rate. All specifications in Table 3 show that the magnitude of negative α_2 is much greater than that of positive α_1. This shows that the hazard rate for the third birth increases at a rate of 0.061 until four years after the second birth and then decreases at a rate of 0.106.

In addition, that short previous birth intervals are associated with a high probability of conception in subsequent births is also supported in the third birth cases. The wife's age is significantly negative with regard to the probability of the third birth in Models 4 and 5.[24] Finally, family income, the wife's employment status, the female's educational level, the influences of the fertility rate, the interest rate, the female unemployment rates, and the cohort variable are all insignificant in the case of third births.

6. Conclusion

Using a sample collected from the PSID data, this article estimates several specifications of the piecewise-linear segment hazard rate model to investigate the influence of the PTE on birth spacing. The estimation results confirm that married couples with a high PTE tend to shorten the length of the second and third birth intervals. Every one-dollar increase in the PTE will significantly reduce the duration of waiting time to the conception of the second child by as much as 0.1 percent and by 0.2 percent for the third child. The hypothesis that the hazard rate for conception initially increases until four years after the previous birth, and then decreases, is accepted only in the case of the third birth.

Table 3
Estimation Results for Third Births

Covariates	Model 1	Model 2	Model 3	Model 4	Model 5
New PTE	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002* (1×10^{-3})	0.002** (0.001)
Income	-1.6×10^{-6} (6.17×10^{-6})	-1.8×10^{-6} (6.16×10^{-6})	-1.9×10^{-6} (6.30×10^{-6})	-1.6×10^{-6} (5.96×10^{-6})	-3.49×10^{-6} (6.66×10^{-6})
Working status	0.359 (0.222)	0.349 (0.222)		0.328 (0.218)	0.401* (0.228)
High-white			–0.334 (0.208)		
High-blue			–0.853 (0.758)		
Age	–0.055 (0.042)	–0.063 (0.044)	–0.052 (0.043)	–0.078** (0.035)	–0.08* (0.042)
Cohort—1940	–0.851 (0.781)	–0.713 (0.828)	–0.878 (0.781)	–0.41 (0.707)	–0.789 (0.865)
Cohort—1950	0.066 (0.352)	0.134 (0.368)	0.043 (0.352)	0.301 (0.262)	0.281 (0.345)
Preceding interval	–0.016*** (0.006)	–0.016*** (0.006)	–0.017*** (0.006)	–0.016*** (0.005)	–0.018*** (0.006)
White	–0.043 (0.533)	–0.028 (0.537)	–0.041 (0.527)	–0.007 (0.532)	
City	–0.012 (0.222)	–0.01 (0.223)	–0.021 (0.221)	–0.006 (0.223)	0.165 (0.22)
North	–0.385 (0.27)	–0.389 (0.27)	–0.396 (0.27)	–0.408 (0.271)	–0.451* (0.273)
South	–0.433* (0.263)	–0.436* (0.264)	–0.434 (0.266)	–0.445* (0.262)	–0.467* (0.278)
West	–0.293 (0.277)	–0.292 (0.277)	–0.269 (0.275)	–0.313 (0.276)	–0.392 (0.287)
Interest	0.044 (0.053)	0.079 (0.081)	0.04 (0.053)		0.025 (0.056)
Fertility	–0.039 (0.071)	–0.068 (0.088)	–0.04 (0.071)		–0.041 (0.074)
Unemployment	0.035 (0.124)	0.091 (0.161)	0.026 (0.124)		2×10^{-4} (0.129)
Education	–0.082 (0.247)	–0.083 (0.246)	0.013 (0.245)	–0.06 (0.244)	–0.098 (0.254)
Year		0.063 (0.114)			
Constant	–1.604 (5.169)	–5.671 (9.014)	–1.122 (5.141)	–3.058*** (0.933)	–0.584 (5.307)
Duration dependence					
α_1	0.064 (0.099)	0.055 (0.099)	0.061 (0.1)	0.061 (0.098)	0.085 (0.099)
α_2	–0.166** (0.079)	–0.162** (0.079)	–0.164** (0.08)	–0.171** (0.077)	–0.181** (0.08)
No. of subjects	460	460	460	460	438
No. of failures	111	111	111	111	106
Log likelihood	–843.465	–842.285	–841.344	–847.434	–811.076

Note: Numbers in parentheses are standard errors. Standard errors adjusted for clustering on the subject-id variable. Asterisks indicate significance at the (*) 10-percent, (**) 5-percent, and (***) 1-percent levels, respectively, for the two-tailed test.

In addition, a macro-level factor, the total fertility rate, is an important determinant in the decision of the timing of the second birth. However, economic factors do not play an important role in married couples' decisions regarding when to have their third child. This study also shows that there is a strong positive relationship between the previous and subsequent lengths of birth intervals. Furthermore, cohort effects on the spacing of births seem to be insignificant.

Previous studies suggest that government policies may affect the timing of births. For instance, Maxwell (1991) suggested that policies enhancing employment and wages for Black people could cause them to delay having their first child. In addition, a reduction in poverty among Blacks might lead to a reduction in the rate of teenage pregnancies. This research also provides evidence that a change in government tax policies, such as a change in the tax bracket or the statutory PTE, could affect people's decisions regarding the timing of second and third births. The magnitude of the influence is small but is, nevertheless, significant.

Notes

1. In the United States, there are also other subsidies available to families with children, such as Aid to Families with Dependent Children (AFDC), the earned income tax credit (EITC), and so on. Huang (1998b) showed that the EITC has a positive influence on the decisions of low-income families to have their first child.

2. In this model, the representative wife is assumed to pursue her maximum utility by choosing the optimal bundle of goods and children under the constraint that after-tax family income, including both wife's earnings and nonlabor income plus the total value of the PTE, must equal the total expenditure on consuming goods and children. It is also assumed that there is a certain relationship between exposure to the risk of having children and fertility.

3. Both studies conclude that the PTE encourages people to have children at the end of the year, rather than at the beginning of the following year.

4. Cain and Weininger (1973) proved that the female wage rate has a negative effect on the number of children she bears, and the authors also find that both female education and male earnings have a negative effect on fertility. Blau and Robins (1989) investigated the negative impact of child care costs on the fertility decision. Mocan (1990) investigated the behavior of fertility during the business cycle.

5. By using U.S. time-series data from 1913 to 1984, different lagged specifications of the aggregate fertility equation were adopted to estimate the fertility effect of tax exemptions for dependent children.

6. They argued that a linear structure for the real-value PTE, adopted in the study of Whittington, Alm, and Peters (1990), may provide an inaccurate prediction of the effect that any change in the exemption may have on fertility.

7. The static lifecycle model fails to address the way in which government tax policies can affect the spacing decision of fertility (e.g., Happel, Hill, and Low 1984), whereas the

dynamic model shows that parents' decisions on the timing of births depend on the costs involved in having a child at each point in time. If the cost of having a child at $t+1$, discounted back to time t, is lower than the cost at time t, parents will delay any birth planned for t to $t+1$, and vice versa (e.g., Cigno and Ermisch 1989). This dynamic model also postulates that an increase in child benefits will reduce the tempo of fertility. The tempo of fertility is defined in Barmby and Cigno (1990) as the expected time to the first birth. It can also be defined as the proportion of completed fertility finished in the first three or four years of marriage, as in Cigno and Ermisch (1989). However, Barmby and Cigno (1990) did not support this postulation because of the uncertainty and imperfections in the capital market.

8. Married couples cannot take into consideration the full amount of the statutory PTE for an additional child. The amount of the reduction in the tax liability is only the product of the marginal tax rate and the statutory PTE. This amount could be a maximum because of the possibility of moving to a lower marginal tax rate level as married couples have an additional child.

9. Indeed, there is a tradeoff between the quality and quantity of children. This conclusion is suggested by Becker (1960), Becker and Lewis (1973), and Becker and Tomes (1976). As assumed in the theoretical model, the quality of children is defined as the total amount of time that the mother spends caring for her children. Therefore, the longer the interval between births, the higher the quality of the children they will have. The author would like to thank the referee for pointing this out.

10. Because the proportion of time that the mother works at home during the childrearing period is equal to 1, the time interval between births represents the quality of children in this simple model.

11. These assumptions are as follows: $U_{BG} < 0$; $U_{GG} < 0$; $B > 1$; the parents' spending on consumption exceeds the difference between the net child cost and the wife's earnings net of taxes; the total family earnings exceeds the total statutory PTE for all children; the total statutory PTE for $(B-1)$ children is greater than the wife's earnings. They are also necessary conditions for the positive relationship between the PTE and the demand for children. More detailed information is available on request.

12. This technique has been applied to analyzing such issues as the duration of waiting times for conception, the period of unemployment, strike duration, the timing of business failures, the interval between arrests, the length of survival time after the diagnosis of a disease or after an operation, the time to repurchasing, the age at marriage, and so on (Greene 1993).

13. A duration independent hazard rate implies that the hazard rate function is a constant term.

14. In the sample used in this study, the hazard rates of the second and third conceptions are found to reach a maximum in four years after the preceding birth. A detailed description is available on request.

15. Regarding the four-year period of an increasing hazard identified in the article, this is based only on the data that I observed. According to Table 1, the average wife's age is 27.89 in the case of the second birth, and 31.3 in the case of the third birth.

16. The author totally agrees that the exogeneity of marital status assumed in the article is potentially problematic. As considering the causality between children and marriage status will make the issue discussed in this study more complicated, this study limits the sample to married couples. Therefore, the conclusions reached in this study can only apply to married couples. In addition, doing so could also avoid the issue that groups with different marital statuses have to use different variables in their regressions. For example, the information regarding the husband's annual earnings is not available for women who were never married or got

divorced and subsequently remarried. The author fully understands the referee's concern and would like to thank the referee for the comments and suggestions.

17. This is because the first birth interval is open on the left-hand side; that is, there is no information on those whose first conception began before their marriage.

18. In this sample, some women with one child or two children were not pregnant but were fertile at the end of 1991.

19. This may be the result of an ovulation after birth. In addition, the duration of temporary sterility may last much longer with breastfeeding. For simplicity, two months' duration is used as the average duration of temporary sterility.

20. A detailed description of the calculation of the new marginal tax rate is available on request.

21. Indeed, there is a strong link between income/wealth and fertility. Controlling for income in the regressions (hazard models) might not be sufficient to resolve this potentially serious weakness. Because the information concerning family wealth is not available in the data that this study adopts, the variable of family wealth is not included in the regression model. This issue also exists in many studies, including Whittington, Alm, Peters (1990), Whittington (1992), Georgellis and Wall (1992), and so on. None of these articles consider the effect of wealth on the fertility decision either. The author is deeply appreciative of the referee's comment in this regard.

22. It is true that running separate regressions for different income groups (e.g., "rich" versus "poor") enable us to compare empirical results between (among) different income groups. I totally agree with the referee's idea that doing this could be a way forward. However, making a comparison between (among) different income groups in this regard will not only make this study more fruitful but also more complicated. In order for this study to focus on the issue of the influence of the PTE on the birth interval, this study leaves the comparison as a topic for further study. The author appreciates the referee's suggestion.

23. In addition, the proportional hazard rate model is also estimated. The estimation results are similar to those of the piecewise-linear segment hazard rate model with an exponential distribution. The estimation results are available on request.

24. The different results between the second and third births may be because of the fact that the woman's current age during the third birth interval is greater than that during the second birth interval shown in Table 1. Since a female's fecundity decreases as age increases, the magnitude of the decrease in the interval to the third birth is more significant and greater than in the case of second births. Hence, it is concluded that the negative net age effect on the length of the birth interval appears in the third birth but not in the second birth.

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