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PERSONAL TAX EXEMPTION: THE EFFECT ON FERTILITY IN TAIWAN

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I. INTRODUCTION

THE advancing age of Taiwan's population is regarded as a serious problem that has been a cause for growing concern in recent years. The problem is illustrated by the upward trend in the ratio between the total population and people over the age of sixty-five, and the downward trend of the general fertility rate (GFR, hereafter).[1] Figure 1 shows that the proportion of the total population over the age of sixty-five was 8.19 per cent in 1998, up from around 5.28 per cent in 1986, and this was accompanied by a simultaneous decline in the GFR from 6 per cent in 1986 to 4.3 per cent in 1998.

These two distinct features—two of the three features identified by Leete (1987)—have pushed Taiwan, and many other countries in East and Southeast Asia, into a post–demographic transition phase.[2] In an attempt to mitigate this population-aging problem and to avoid some of the socioeconomic issues created by the phenomenon, many regional economists and sociologists now suggest that measures are required to actively encourage people to have more children.

In order to provide such encouragement in Taiwan, one first needs to understand the determinants of the people's demand for children, but there are, of course, many factors that affect fertility behavior. Temperature, for example, has a significant influence on the timing of birth (Seiver 1985; Land and Cantor 1993; Lam and Miron 1996). The economic theory of fertility sees the demand for children mod-

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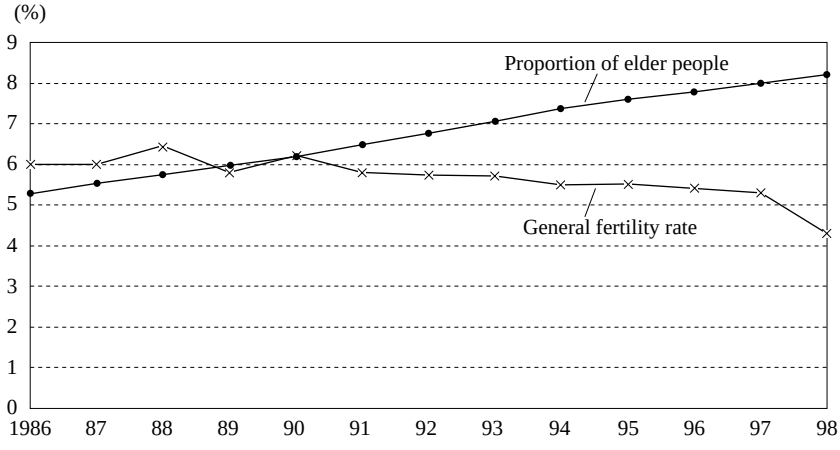
[1] The definition of the general fertility rate is the birth rate per thousand women between the ages of fifteen and forty-nine.

[2] Leete (1987) characterizes three distinctive features of the post-demographic transition phase of several countries in East and Southeast Asia. They are the postponement of death, a conspicuous rise in the age at marriage, and an avoidance of births.

Fig. 1. General Fertility Rate and the Proportion of the Population over Sixty-five Years of Age, 1986–98



Source: Data is provided by the Department of Health, the Executive Yuan, Taiwan.

eled as a utility maximization problem which is subject to income constraints; a couple's demand for children will depend upon the relative magnitude of the marginal utility and upon the marginal cost of having children. If a couple's marginal utility is greater than the marginal cost, then the couple will decide to have children, and vice versa. However, while marginal utility—which represents people's preferences—varies amongst different people, marginal cost is affected by external economic factors, such as the wife's wages, family income, and so on.

The personal tax exemption (PTE, hereafter) of a family income tax can reduce the cost of bringing up children and can therefore help to encourage people to have more children. However, although the PTE's positive influence on the number of births and birth rate has been proven in the United States, the hypothesis has not yet been examined in Taiwan. The present paper utilizes official regional-based panel data on Taiwan during the period 1990 to 1996 to investigate the relationship between PTE and GFR in Taiwan.

After deflating the data and estimating different specifications of the fixed-effects model, the estimation results demonstrate that the PTE value exerts a positive and statistically significant effect on GFR. However, the magnitude of the influence is small, with a one-thousand NT dollar increase in the real value of PTE causing an increase of just 1.2–1.4 births per thousand women. This conclusion also holds after excluding the wife's earnings in the empirical model for the sake of the potential endogeneity between wife's earning and fertility. Thus, this suggests that a family income tax policy may be an effective means of increasing GFR and hence providing assistance in mitigating Taiwan's population-aging problem. However, it

is clear that the cost to the government to induce a single additional birth is extremely high.

The remainder of this paper is organized as follows: a review of the literature on birth behavior is carried out in Section II, followed by a description of the PTE-fertility relationship in Section III. Section IV provides descriptions of the empirical model and variable statistics, with an analysis of the empirical evidence and policy implications outlined in Section V. Finally, conclusions are drawn and discussed in Section VI.

II. REVIEW OF LITERATURE ON BIRTH BEHAVIOR

Ever since Becker (1960) and Schultz (1973) 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).[3] A number of empirical studies have also investigated the same issues in respect to Taiwan. Mueller and Cohn (1977) concluded that 1966 Taiwan data did not demonstrate a positive income-fertility relationship. This finding also holds after considering attitude differentials. Furthermore, Schultz (1988) found that Taiwan's family planning program was particularly effective in reducing birth rates in some specific regions.[4]

Some social and cultural factors are also related to the demand for children. Yen, Yen, and Liu (1989) suggested that preference heterogeneity, family structure complexity, and rural-urban development trends should all be explicitly taken into account in an explanation of fertility in Taiwan. In addition, Yen and Yen (1992) indicated that the wife's education had a negative influence on the desired number of children in Taiwan.[5] However, Liu (1995) points out that any influence on Taiwan's fertility rate by socioeconomic factors is shown to be minor, and direct institutional factors are the best way of returning fertility to a stable replacement level. Furthermore, Cheng and Nwachukwu (1997) demonstrated that education has no significant influence in Taiwan, which is contrary to the results of several other studies.

The main concern of this study is the extent to which PTE affects fertility behavior in Taiwan. In order to understand this relationship, a theoretical model and a

[3] Cain and Weininger (1973) proved that the female wage rate has a negative effect on the number of children she bears, while the authors also found that both female education and male earnings have a negative effect on fertility. Blau and Robins (1989) investigated the negative impact of childcare costs on the fertility decision. Mocan (1990) investigated the behavior of fertility over a business cycle.

[4] These regions are characterized as being predominantly agricultural, with low child mortality, and a high proportion of children already in school.

[5] They suggested that this conclusion was comprised of two issues: (i) the effect of the opportunity cost of the wife's time in raising up children; and (ii) the attitudinal effect.

number of empirical results are introduced in the following section.

III. PERSONAL TAX EXEMPTION AND BIRTH BEHAVIOR

Although many scholars maintain that a PTE's fundamental purpose is to relieve the tax burden of low-income families, some economists have recently begun to study the effect that a PTE has on family decisions. The value of a PTE for a specific family has been defined, in Whittington, Alm, and Peters (1990), as the product of the statutory value PTE and the couple's marginal tax rate.

$$PTE = (\text{real statutory value PTE}) \times (\text{marginal tax rate}). \tag{1}$$

This value is the total reduction (with the associated tax benefit) in the cost of raising a child.[6] It varies across families as a result of differing marginal tax rates within different families.

A. *Theoretical Model*

Georgellis and Wall's (1992) theoretical "model of fertility choice" provides a clear understanding of the PTE-fertility relationship. In this model children enter the utility function in the same manner as traditional commodities, and it is assumed that all nonmarket time is spent exclusively on raising the child. The representative wife is assumed to be pursuing her maximum utility by choosing the optimal bundle of goods and children. Her utility is a function of the amount of goods consumed, G, and the number of children, C. However, C is equal to the number of live births, B, times the infant survival rate γ. Assuming there is a certain relationship between exposure to the risk of having children and fertility, the number of live births is thus the exposure to risk e minus the number of times the exposure was controlled, ρ.[7]

With regard to the budget constraint, it is assumed that the commodity price is equal to one, the amount spent per child is P, and each child requires one unit of time. The total available time T is distributed between work and children. Therefore, after-tax family income, including both the wife's earnings and nonlabor income, plus the total value of PTE must equal the total expenditure on consuming goods and children. The utility maximization problem is as follows:

$$\begin{aligned} &\text{Max} \quad U\,[G, (e - \rho)\gamma] \\ &\text{s.t.} \quad Y + w\,[T - (e - \rho)\gamma] = G + (P - X)(e - \rho)\gamma, \end{aligned} \tag{2}$$

[6] Married couples cannot take the full amount of the statutory personal exemption of tax deduction for an additional child. The amount of reduction in the tax liability is only the product of the marginal tax rate and the statutory PTE. This amount could be a maximum due to the possibility of changing into a lower marginal tax rate level when married couples have an additional child.

[7] In Georgellis and Wall's paper, this birth control parameter ρ captures the degree of control that a woman has over the number of births that occur.

where Y, w, and X are the after-tax nonlabor income, the wife's after-tax market wage rate, and the value of the PTE, respectively.

After solving this problem, the demand for children will be obtained by using the demand of exposure to the risk of childbearing e, minus the birth control parameter ρ.

$$B = e\,(Y, w, X, \rho, \gamma) - \rho. \tag{3}$$

The value of PTE, X, clearly plays a role in a family's fertility behavior. Since it represents a direct subsidy towards lowering the price of each child,[8] the existence of PTE creates an economic incentive, ceteris paribus, for a family to have more children.

B. *Empirical Literature*

The first empirical study investigating the GFR-PTE relation was a time-series analysis conducted by Whittington, Alm, and Peters (1990). Using U.S. time-series data from 1913 to 1984, the authors adopted different lagged specifications of the aggregate fertility equation to estimate the fertility effect of tax exemptions for dependent children. The central finding of their paper was that the real value PTE has a positive and statistically significant effect on the national birthrate.

Georgellis and Wall (1992), in a different vein, argue that a linear structure for the real value PTE that was adopted in the study by Whittington, Alm, and Peters (1990) may provide an inaccurate prediction of the effect that any change in the exemption may have on fertility. They added a quadratic variable for the real value PTE into the fertility regression models and obtained a diminishing marginal influence from an increase in the federal income tax PTE on the fertility rate. 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 into the regression models. Their empirical results further support the conclusion that a 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 Panel Study of Income Dynamics data (PSID, hereafter) and conditional logit models with different lagged specifications in order to show that an increase in a specific family's real value PTE raises the likelihood that they will have an additional child. In addition, Whittington (1993) also examined the influence of a state income tax PTE—another kind of subsidy for families raising children—on a couple's decision to have children. Empirical results do not, however, support the author's hypothesis.

[8] 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 (1998) shows that the EITC has a positive influence on the decisions of low-income families to have their first child.

The focus of the present study is the importance of a PTE on a couple's decision whether or not to have children in Taiwan. While the positive influence of a PTE on the number of births and on fertility rate has been proven in the United States, the hypothesis has not yet been examined for Taiwan. In the following sections, official data from Taiwan's government and several specifications of the empirical model will be utilized to explore this issue in Taiwan.

IV. EMPIRICAL MODEL AND DESCRIPTION OF VARIABLES

In order to make inferences about the responsiveness of GFR in Taiwan to changing socioeconomic factors (particularly to any change in PTE), a regional cross sectional data time series is adopted. The advantage of using this regional-based panel data is that it allows for the consideration of more availability of econometric models; for example, the fixed-effects model with an intercept variable.[9] The fixed-effects model is a simple way to consider the heterogeneity across regions and/or through time, and this varying intercept can take account of the effect of all omitted independent variables.[10] In this research, all omitted variables considered are regional time-invariant; for instance, culture and some other regional attributes. Hence, we focus only on regional-specific effects. This fixed-effects model can be written as follows.

$$Y_{it} = \alpha_i + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots + \beta_k X_{kit} + u_{it}, \tag{4}$$

where $i = 1, 2, \ldots, N$; $t = 1, 2, \ldots, T$; and u_{it} is an independently identically-distributed random variable with mean zero and variance σ_u^2.

Equation (4) implies that differences across units can be captured in differences in the constant term, and α_i is taken as a regional specific constant term. The Lagrange multiplier (LM) test devised by Breusch and Pagan (1980) will be adopted to examine the existence of the regional-specific effects.[11]

[9] In this study, another variable-intercept model, the random-effects model, is not considered. According to Hill, Griffiths, and Judge (2001), the random-effects model is very useful if the individual regions (or cross-sectional units) appearing in the sample are randomly chosen and taken to be representative of a larger population of regions. However, the individual regions utilized in this study are the whole population and are not chosen randomly from a larger population of regions. Therefore, this study does not consider the random-effects model. The Hausman test proposed by Hausman (1978) will be used to test the hypothesis of whether the regional-specific effects are uncorrelated with other regressors in the model.

[10] The intercept variable has three types: individual time-invariant, period individual-invariant, and individual time-varying variable. As discussed in Hsiao (1995), running a least-squares regression with pooling data may lead to a false inference if the postulation is rejected that the regression parameters take a value common to all cross-sectional units for all time periods.

[11] Its test statistics distribute as a chi-square distribution and its degrees of freedom are the same as the number of constraints.

The official 1990–96 regional-based panel data adopted in this research covers sixteen counties and seven cities within Taiwan,[12] and uses data from the departments of statistics at the Ministry of the Interior and the Ministry of Finance, and the Department of Health in the Executive Yuan, Taiwan. The reason for a discussion of the PTE-fertility relationship exclusively during this period is that continuous data on the average marginal tax rate for each region (the primary factor for generating the value of PTE) is available only for the period 1990–96. Thus, the number of observations is 161, i.e., $N = 23$ and $T = 7$ in equation (4).

The dependent variable (GFR) is defined as the birthrate per thousand women aged between fifteen and forty-nine. The advantage of the GFR against the crude birthrate is that the former is less sensitive to changes in the age and sex structure than the latter (Whittington, Alm, and Peters 1990). Due to obvious biological constraints, there is a time lag between having all economic information and making the decision to have children and also a time lag between making the decision and giving birth. Thus, it is reasonable to estimate the fertility equation in lagged form.[13] Since the correct lag structure is difficult to identify, three specifications of the lag structure are considered; they are: one-year lag, two-year lag, and weighted lag.

Given the pregnancy gestation period of nine months, the second specification is more reasonable than the first one, because people have all the necessary information regarding the previous year, and they subsequently make a decision to have children in the current year. Consequently, their children are more likely to be born in the next year, rather than in the current year.

In order to further capture the feature of the probability of giving birth in the current year, vis-à-vis the following year, a weighted lag structure combining the GFR of the current year and the following year with the respected weight of 0.25 and 0.75 is thus utilized.[14] The fertility equation estimated in this study is as follows.

[12] The sixteen counties are Taipei, Ilan, Taoyuan, Hsinchu, Miaoli, Taichung, Changhua, Nantou, Yunlin, Chiayi, Tainan, Kaohsiung, Pingtung, Taitung, Hualien, and Penghu, and the seven cities are Keelung, Hsinchu, Taichung, Chiayi, Tainan, Taipei, and Kaohsiung.

[13] The certain relationship between conception and birth is assumed in this study. One may wonder how a couple can control the conception-birth relationship, because some pregnancies may not go to term (i.e., premature births, miscarriages, or abortions may occur), or may result in stillbirths. Indeed, as Cigno (1994) points out, the impact of such uncertainty on an individual's decision making must be taken into account. However, since such uncertainty happens randomly, ignoring it avoids the introduction of biased estimation. For the sake of simplicity, this study focuses only on the subsample containing live births.

[14] The two-year lag and one-year lag structure allow the pregnancy gestation period to be more than or less than nine months. The pregnancy gestation period is thus more flexible for the two-year lag structure than for the weighted lag structure. Nevertheless, the purpose of using three lagged structures in this study is to test the robustness of a PTE's influence on fertility.

$$GFR_{it} = \alpha_i + \beta_1 PTE + \beta_2 \text{income} + \beta_3 \text{wife's earnings} + \beta_4 \text{ratio of aboriginal} + \beta_5 \text{ratio of contraceptive uses} + \beta_6 \text{infant mortality rate} + \beta_7 \text{unemployment rate} + \beta_8 \text{wife's education} + \beta_9 \text{time trend} + u_{it} \quad (5)$$

The focus of the explanatory variable is the PTE, equal to the amount of the statutory personal tax exemption multiplied by the average marginal tax rate per household for each region in each year. Taiwanese taxpayers with children under the age of twenty are eligible to apply for the personal tax exemption scheme. If their children are above the age of twenty, but are still full-time students, then taxpayers can enjoy the tax exemption as well. That is to say, people can enjoy this tax benefit at least nineteen years if they have an additional child.[15] Following the economic theory, as mentioned earlier, the relationship between a PTE and the demand for children should be positive. The coefficient of PTE is thus expected to be positive.

Additional explanatory variables include economic and demographic variables that can affect both the demand and supply of births. Family income is measured as the difference between the average family income, the sum of the average family tax payment, and the average wife's earnings in each region.[16] It is worth noting that the explanation of the sign of family income's coefficient should be done very carefully. It cannot be concluded whether children are normal or inferior goods due to the use of regional panel data instead of family-level data. Since female earnings are treated as a time cost for women, the wife's earnings are included in this model as the opportunity cost of childrearing.[17] It is expected that the regional GFR will be lower when the average regional wife's earnings increase.

Aboriginal Taiwanese people may demonstrate somewhat different fertility behavior from that of people of other origins in Taiwan. In general, it is culturally acceptable, and thus more likely, for aboriginal people to have more children. Hence, a higher proportion of aboriginal people has the potential of producing a higher fertility rate. The use of any form of contraception will, of course, reduce the prob-

[15] This personal tax exemption scheme is only for those who have to pay the family income tax. If people's income is too low to pay the family income tax (i.e., their marginal tax rate is zero), then the personal tax exemption is irrelevant to them. In addition, the number of tax dependents in a family income tax is not restricted in Taiwan.

[16] The definition of family income in this study is defined to be similar to the definition of income in Whittington, Alm, and Peters (1990). However, male earnings and non-wage family property income are actually unavailable. Instead, three variables of the average family income, average wife's earnings, and average family tax payment in each region are available in this study. Therefore, the above three variables are used to calculate the family income. The definition of family income in this study is thus the difference between the average family income, the sum of average family tax payment, and average wife's earnings in each region.

[17] The use of average wife's earnings instead of average wife's wage rate as her opportunity cost of childrearing comes about as a result of the unavailability of the average wife's wage across certain regions in Taiwan.

ability of conception, and further lower the fertility rate; the coefficient of contraception should therefore be negative.

As Whittington, Alm, and Peters (1990) pointed out, the infant mortality rate has two effects: (i) the replacement effect, which causes a higher fertility rate if the infant mortality rate increases; and (ii) the cost effect—so-called because infant mortality increases the cost of having a surviving child. If the cost effect dominates the replacement effect, then an increase in the infant mortality rate will bring about a lower fertility rate.

The unemployment rate has also been shown to influence fertility behavior. Since married couples' expectations with regard to their future working situation are also affected by the unemployment rate, a high current unemployment rate may create an expectation amongst couples that, in accordance with the normal business cycle, the economy will return to a higher level in the future. Hence, a high unemployment rate may encourage couples to have more children, and thus raise the fertility rate. However, as Mocan (1990) indicated (in Section II), the relationship between unemployment and fertility is reliant upon the type of empirical model; thus, the relationship between unemployment rate and fertility rate is ambiguous. Moreover, as Cain and Weininger (1973) demonstrated, female education and male earnings both have a negative effect on fertility. In this study, a negative relationship between female education and fertility is expected.

The value of PTE, the regional average family income, and the regional average of a wife's annual earnings have been deflated by the consumer price index (hereafter, CPI) to control the fluctuation of prices. The variable definitions, statistics, and expected sign are described in Table I.[18]

V. ESTIMATION RESULTS AND POLICY ANALYSIS

In this study seven specifications of the fertility equation have been conducted to analyze the impact of real value PTE on GFR. Model 1 is a non-lagged fertility

[18] As a matter of fact, women's participation rate in the labor force, education cost for children, residential cost to cover rooms for children, and the availability of daycare nurseries or nursery schools have been considered in the empirical model. However, if these variables are added into the empirical model, some problems will come out. The women's participation rate in the labor force might cause a potential endogeneity with fertility, because women's decisions regarding fertility might affect their decision regarding labor supply, and vice versa. With respect to the education cost for children, it does not vary across regions in Taiwan in a specific year. Moreover, this cost is always adjusted based on the inflation. Its real value also does not have a sufficient variation during the referred period and across regions and causes an insufficient variation problem in estimation. The same problem also appears in the estimation as we consider the variable of residential cost to cover rooms for children in the regression. Finally, the availability of daycare nurseries or nursery schools varies across regions in a specific year, but not so across years in a specific region. Thus, the influence of the availability of daycare nurseries or nursery schools on regional GFR has been included in the parameter α_i in equation (5).

TABLE I

VARIABLE DESCRIPTIONS AND STATISTICS

Variable	Definition	Mean	S.D.[a]	Sign
GFR	General fertility rate of the current year: births per 1,000 women aged 15–49 (‰)	59.7329	8.01308	
GFR1	General fertility rate of the next year (‰)	58.6646	7.96472	
GFR2	General fertility rate of the year after the next year (‰)	56.5839	9.00108	
GFR3	Weighted general fertility rate (‰): The weights for GFR and GFR1 are 0.25 and 0.75, respectively.	57.104	8.60321	
PTE	Real value of personal tax exemption per household (CPI = 100 in 1996) (NT$/per year)	6,108.67	1,287.7	+
Family income	Average real after-tax family income net of wife's earnings per household (CPI = 100 in 1996) (NT$/per year)	372,629	71,583.5	?
Wife's earnings	Wife's average real after-tax earnings (NT$/per year)	171,603	37,803.8	–
Aboriginal	The proportion of aboriginal people (%)	3.41242	7.46386	+
Contraception	Proportion of married women aged 20–44 who adopt the use of any contraceptives (%)	4.33435	2.32941	–
Infant mortality	Ratio of deaths under one year old to number of live births	5.91634	1.47422	?
Unemployment	Annual unemployment rate (%)	1.77658	0.65036	?
Female's education	Proportion of women's educational level being college or above (%)	2.29422	1.5611	–
Time trend	Time trend = 1 in 1990 and increases by 1 each year	4	2.00624	–
Observations	161			

Sources: The departments of statistics at the Ministry of the Interior and the Ministry of Finance, and the Department of Health, the Executive Yuan, Taiwan.

[a] Standard deviation.

equation form, and GFR1, GFR2, and GFR3 are dependent variables in Models 2, 3, and 4, respectively. Models 5, 6, and 7 are counterparts of Models 2, 3, and 4, respectively, with the difference being the exclusion of the regional average of a wife's earnings in each model, in order to avoid the potential endogeneity between fertility and wife's earnings.

Based on the LM test in Table II, it is clear that there are regional-specific effects.

TABLE II

THE ESTIMATION RESULTS OF DIFFERENT SPECIFICATIONS OF THE FIXED-EFFECTS MODEL

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
PTE	–0.0012***	0.0006*	0.0014**	0.0012***	0.0006	0.0014**	0.0012***
	(–2.982)	(1.655)	(2.588)	(2.797)	(1.571)	(2.573)	(2.770)
Family	8.95E-06***	3.69E-06	8.03E-06	6.95E-06	5.44E-07	7.63E-06	5.86E-06
income	(3.312)	(1.297)	(1.080)	(1.169)	(0.195)	(0.884)	(0.831)
Wife's	–2.12E-05***	–9.29E-06*	–1.18E-06	–3.21E-06			
earnings	(–4.508)	(–1.808)	(–0.114)	(–0.389)			
Aboriginal	6.116***	1.493	1.583	1.560	1.572	1.593	1.587
	(3.674)	(1.015)	(0.509)	(0.621)	(1.061)	(0.513)	(0.631)
Contra-	0.233	0.166	–0.683***	–0.471***	0.180	–0.681***	–0.466***
ception	(1.571)	(0.968)	(–2.882)	(–2.648)	(1.047)	(–2.908)	(–2.654)
Infant	0.127	0.096	–0.146	–0.085	0.104	–0.145	–0.083
mortality	(0.861)	(0.839)	(–0.683)	(–0.540)	(0.915)	(–0.683)	(–0.527)
Unem-	–0.911***	–0.443*	–3.845***	–2.994***	–0.433*	–3.843***	–2.991***
ployment	(–3.085)	(–1.757)	(–6.694)	(–6.830)	(–1.694)	(–6.723)	(–6.857)
Female's	0.504	–0.131	–0.042	–0.064	–0.124	–0.041	–0.062
education	(1.322)	(–0.335)	(–0.059)	(–0.111)	(–0.320)	(–0.058)	(–0.106)
Time trend	–0.295	–0.765***	–2.853***	–2.331***	–0.781***	–2.855***	–2.337***
	(–1.253)	(–2.977)	(–7.268)	(–7.781)	(–2.993)	(–7.333)	(–7.834)
Adjusted R^2	0.957	0.967	0.916	0.942	0.967	0.917	0.943
LM test	44.227	62.093	17.442	27.976	62.537	17.578	28.185

Notes: 1. The values in parentheses are *t*-statistics.
2. Definition of Model:
Model 1. GFR as the dependent variable.
Model 2. GFR1 as the dependent variable.
Model 3. GFR2 as the dependent variable.
Model 4. GFR3 as the dependent variable.
Model 5. Same as Model 2, but excluding wife's earnings in the empirical model.
Model 6. Same as Model 3, but excluding wife's earnings in the empirical model.
Model 7. Same as Model 4, but excluding wife's earnings in the empirical model.

* Significant at 10 per cent level.
** Significant at 5 per cent level.
*** Significant at 1 per cent level.

In other words, the fixed-effects approach is better than the classical approach. The estimations of seven fixed-effects models, taking into account heteroskedasticity, are reported in Table II.[19]

A. *Estimation Results*

Only in Model 1 is the coefficient of real value PTE significantly negative; in

[19] The estimated regional-specific effect α_i for each region in equation (5) is provided in the Appendix Table I. All regional-specific effects in the three lagged structures are significantly different from zero, except for Chiayi City and Tainan City.

other specifications, it is statistically significant and positive. The biological constraints, mentioned in Section II, create the time lag between the birth decision and actually giving birth. It is reasonable therefore to estimate the fertility equation in lagged form. Hence, the use of wrong specifications, such as in Model 1, causes a reverse conclusion. It is also worth reiterating that, as a result of the nine-month gestation period, the two-year lag and weighted lag structures are better than a one-year lag structure. Subsequent the estimations of Models 3 and 4 should therefore have greater validity than that of Model 2. Without the wife's earnings in the empirical model, the estimation results of Models 6 and 7 also show the significantly positive coefficient of PTE.

Referring to the empirical results, this study does suggest a positive PTE-fertility relationship in Taiwan—a conclusion which is consistent with other studies (Whittington, Alm, and Peters 1990; Georgellis and Wall 1992; Gohmann and Ohsfeldt 1994). However, the magnitude of the influence of PTE on GFR is rather trivial; the marginal effect being in the range of 0.0012–0.0014—i.e., a one-thousand NT dollar (approximately U.S.$30, based on a NT$/U.S.$ exchange rate of 33:1) increase in real value PTE—will produce an increase of 1.2–1.4 births per thousand women between the ages of fifteen to forty-nine in Taiwan. After comparing this with the results of Whittington, Alm, and Peters (1990), the marginal effect of a PTE on fertility in Taiwan is even smaller than that in the United States.[20]

Within Table II, there are a number of other factors significantly affecting the demand for children, influences that are consistent with our expectations as shown in Table I. The empirical results from Models 3 and 4 and their counterparts show that contraception exerts a significant negative influence on GFR. As discussed earlier, the unemployment rate has an ambiguous impact on fertility, however, Table II does indicate that a high unemployment rate leads to a low fertility rate. Moreover, the result of significant negative coefficients in the time trend for various specifications is consistent with the actual phenomena over time. That is to say, there is in fact a downward trend in Taiwan's GFR probably due to a decline in the general Taiwanese preference on having children, and also due to a decline in the probability of conception because of modern psychological and biological illnesses during the referred period.[21]

It is shown that the regional average family income has no significant effect on the fertility rate in all specifications except Model 1, and the influence of the re-

[20] In the United States, the marginal effect of PTE on GFR is about 0.16–0.24.

[21] There is also a possibility that the time trend's negative coefficients result from the cross effect of explanatory variables, such as family income, wife's wage, wife's education, and so on. However, the correlation coefficients between the time trend and each of the explanatory variables are not high enough to conclude that there is any collinearity in the regression model, and thus the possibility of this is not very much either.

TABLE III

A 1,000 NT DOLLAR INCREASE IN THE REAL VALUE PTE IN 1994

	Estimate of β_1		
	One-year Lag 0.0006	Two-year Lag 0.0014	Weighted Lag 0.0012
Reduction in government's real family income tax revenue (NT$ billion)[a]	12.448	12.448	12.448
Increase in the number of births[b]	2,577.28	7,853.95	6,400.48
Reduction in tax revenue per births (NT$ million)[c]	48.298	15.8491	19.4482

[a] The reduction in tax revenue (TAX) = $1{,}000 \times \text{CPI}_{1994} \times$ number of family income tax dependency.

[b] Number of children increases ($CHLD$):
One-year lag: $CHLD = \beta_1 \times$ number of women aged between fifteen and forty-nine in 1995.
Two-year lag: $CHLD = \beta_1 \times$ number of women aged between fifteen and forty-nine in 1996.
Weighted lag: $CHLD = \beta_1 \times (0.25 \times$ number of women aged between fifteen and forty-nine in $1995 + 0.75 \times$ number of women aged between fifteen and forty-nine in 1996).

[c] The reduction in real tax revenue per additional child = $TAX/CHLD$.

gional average wife's earnings on the regional GFR is also indecisive.[22] The estimation result of neither family income nor wife's earnings being significant is not a very surprising result in the existing literature.[23] This study obtains the same conclusion, indicating that family income and wife's earnings are both not significant determinants of regional GFR in Taiwan. That is to say, regional GFR is determined by factors other than family income and wife's earnings. Any changes in family income and wife's earnings do not statistically affect the regional GFR. Other demographic factors, such as aboriginal culture, infant mortality, and female education seem to play no important role in the change in Taiwan's regional GFR.

B. *Policy Analysis*

Table III presents a calculation of the side effects of the PTE policy (independent

[22] One interesting question is the different influence of regional average family income on regional GFR across income groups. However, it is very difficult to calculate. If some regions are defined as high-income regions and others are low-income regions, then doing this with a dummy variable in the fixed-effects model will cause the collinearity problem. Another problem is the definition of the high-income/low-income regions.

[23] For example, Whittington, Alm, and Peters (1990) showed an insignificant influence on the U.S. fertility rate of both income and female wage, as did Georgellis and Wall (1992). Whittington (1992) concurred with the common conclusion in fertility research that the influence of income on fertility is negative, but insignificant. This more likely illustrates the theoretically recognized confusion of the price effects of quality and quantity with the income effects, rather than simply indicating that children are an inferior good (Becker and Lewis 1973). Mueller and Cohn (1977) explored the relationship between income and the demand for children in Taiwan in 1966, concluding that the Taiwan data did not demonstrate a positive income-fertility relationship. This finding also holds after considering attitude differentials.

of its positive effect on GFR), based on the Taiwan government's one thousand NT dollar increase in real value PTE through a raise in the statutory value of the PTE in 1994.[24] This policy, on the one hand, reduced the government's real tax revenues in the amount of NT$12.448 billion—or 9.37 per cent of the original total family income tax. On the other hand, if lag structures are one-year, two-year, and weighted lag structures (i.e., $\beta_1 = 0.0006$, 0.0014, and 0.0012, respectively), an increase of one thousand NT dollars in the real value PTE also produced an increase of 2,577.28 births in 1995, 7,853.95 births in 1996, and 6,400.48 births during the following two years, respectively.[25] The implication is that the cost to Taiwan's government, in terms of lost tax revenue, was 48.3 million, 15.8 million, and 19.4 million NT dollars for each additional birth during those periods.

VI. CONCLUSIONS

This study utilized official regional-based panel data for the period 1990–96 to investigate the effect of a personal tax exemption (PTE) on birth behavior in Taiwan. After deflating the data and estimating different specifications of the fixed-effects model, the estimated results demonstrate that the real value PTE exerts a positive and statistically significant effect on regional GFR. However, the magnitude of the influence is small; a one-thousand NT dollar increase in real value PTE will cause an increase of 1.2–1.4 births per thousand women. This conclusion also holds after excluding the wife's earnings in the empirical model for the sake of potential endogeneity between the wife's earnings and fertility. This study thus suggests that the family income tax policy can be an effective means of increasing the general fertility rate, and hence, of mitigating Taiwan's population-aging problem. However, it also demonstrates that the cost, in terms of government revenues, in inducing each additional birth is very high.

On the whole, although the results support the hypothesis that an increase in PTE will lead to an increase in the demand for children, the government has thus far avoided any attempt to utilize this type of tax policy to solve the aging problem in Taiwan.[26] Leete (1994) suggests that economic incentives aimed at encouraging

[24] Governments can increase the value of PTE in two ways; by raising its statutory value, or by increasing the marginal tax rate. The former increases people's personal wealth through a lower income tax burden, while government tax revenues decrease. The latter increases government tax revenues, but people are worse off. After considering the political influence of both methods, governments are more likely to adopt a PTE policy of raising the statutory value of PTE.

[25] This calculation is based on the assumption of a linear relationship between GFR and PTE. However, this study just uses the figures as an example to show how the number of children will increase if Taiwan's government increases the real value PTE by one thousand NT dollars for all families.

[26] The chairperson of the Manpower Planning Department of the Council for Economic Planning and Development (CEPD), Republic of China, suggested in 1999 the use of a PTE tax policy to encourage Taiwanese families to have their third child. However, this suggestion has since been rebutted by many officials within the Ministry of Finance.

childbearing would have to be much more generous than those currently offered in several Eastern and Southeast Asian countries. Under the circumstance that Taiwan's government has not yet adopted any effective policies to encourage people to have more children, using the PTE taxation policy might be an alternative means. Unfortunately, whether or not the experiences in the United States and in Taiwan are unique will not be clear until more studies of this nature are conducted in other countries of diverse cultures and income levels.

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APPENDIX TABLE I

THE ESTIMATES OF REGIONAL-SPECIFIC EFFECT α_i

Regions	Model 5	Model 6	Model 7
Taipei County	51.13	64.73	61.33
	(14.67)	(10.36)	(12.36)
Ilan County	57.36	65.09	63.16
	(19.69)	(12.46)	(15.22)
Taoyuan County	50.47	58.26	56.31
	(17.58)	(11.31)	(13.77)
Hsinchu County	59.33	71.17	68.21
	(12.79)	(8.55)	(10.32)
Miaoli County	56.91	65.23	63.15
	(15.12)	(9.66)	(11.78)
Taichung County	68.29	76.00	74.08
	(10.41)	(6.46)	(7.93)
Changhua County	51.95	59.53	57.63
	(16.03)	(10.24)	(12.49)
Nantou County	64.75	73.52	71.33
	(19.30)	(12.22)	(14.93)
Yunlin County	58.87	66.79	64.81
	(21.47)	(13.58)	(16.59)
Chiayi County	61.87	68.54	66.87
	(25.69)	(15.87)	(19.50)
Tainan County	57.54	67.47	64.99
	(7.58)	(4.96)	(6.01)
Kaohsiung County	66.11	74.35	72.29
	(29.86)	(18.72)	(22.92)
Pingtung County	48.77	58.15	55.81
	(16.72)	(11.11)	(13.43)
Taitung County	46.44	53.83	51.98
	(15.45)	(9.99)	(12.14)
Hualien County	66.78	75.28	73.16
	(26.15)	(16.43)	(20.11)
Penghu County	56.89	64.83	62.84
	(23.68)	(15.05)	(18.37)
Keelung City	53.95	63.67	61.24
	(17.85)	(11.75)	(14.23)
Hsinchu City	50.41	59.96	57.58
	(5.38)	(3.57)	(4.31)
Taichung City	54.25	66.76	63.63
	(19.73)	(13.54)	(16.25)
Chiayi City	24.98	37.13	34.11
	(0.65)	(0.54)	(0.63)
Tainan City	15.37	27.56	24.53
	(0.30)	(0.30)	(0.34)
Taipei City	41.20	48.37	46.57
	(10.33)	(6.76)	(8.20)
Kaohsiung City	43.93	52.64	50.47
	(14.21)	(9.49)	(11.46)

Note: Numbers in parentheses are *t*-statistics.