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The Influence of College Tuition and Fees on Fertility Rate in Taiwan

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Abstract This study investigates the influence of college tuition and fees (CTF) on fertility behavior as a mechanism to induce population growth. Using a fixed-effect regression model with various specifications of the fertility equation on contiguous panel data for the period 1990–2001, this study has determined of that CTF has a significantly negative influence on regional GFR (general fertility rate) in Taiwan. In addition, unemployment rates also have a negative impact on fertility though the male rate plays a greater role in the fertility decision than the female rate. Finally, this study calculates the cost in terms of CTF to the Central Government to induce population growth. For a 1% decrease in real CTF, the cost to the government and taxpayers at large, the cost of each additional child will range from US$90.31 to US$252.23 depending on the years considered and the model specifications.

Keywords: College tuition and fees · General fertility rate · Higher education · Taiwan

Introduction

Population data from the Ministry of the Interior at the Executive Yuan, Taiwan, shows that the number of children born in 2004 was 211,000 reached an all-time low,

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16,000 less than the previous year. Compared to the world fertility rate (2.8 births per woman of childbearing years) Taiwan's fertility rate was 1.24, ranked as the second lowest worldwide. The Taiwanese government regards this as a serious problem since it indicates an aging transition loom in Taiwan's not-so-distant future. A population aging transition is determined by comparing the proportion of people over the age of 65 to the general fertility rate (GFR)[1]. Since, in many developed nations, the aging portion of the general population is advancing while general fertility declines, a serious productivity gap seems inevitable.

Data from Taiwan's Department of Health indicates that the aging portion of the population is increasing: in 2003, it was 9.00% up from 5.28% in 1986. Over this period, the general fertility rate declined from 6.0% to 3.6%. These are among the features identified by Leete (1987) that have pushed many countries in East and Southeast Asia into a post-demographic transition phase[2]. To deflect the socioeconomic issues that arise from this phenomenon such as high dependency burden, many regional specialists now suggest that measures must be taken to actively encourage couples to have more children.

Of course, many factors affect fertility. Becker (1960) and Schultz (1973) constructed the primary Economic Theory of Fertility to analyze fertility behavior. Since then, an abundance of empirical evidence has been assembled to explore the influence of economic factors on the demand for children (e.g., Cain & Weininger, 1973; Blau & Robins, 1989; Mocan, 1990; Huang, 1998; Huang, 2002; Huang, 2003). In this theory, the demand for children is determined by using a utility maximization model subject to income constraints. This demand depends on the magnitude of both the marginal utility and the marginal cost of having children. If a couple's marginal utility is greater than its marginal cost of having children, they will decide to have children. Since a couple's preferences, as measured in terms of marginal utility, vary greatly, their marginal cost will also vary according to external factors such as her wages, family income, and so on. Hence, to provide encouragement for Taiwanese couples to increase their fertility, this study can use these measures to analyze their demand for children.

College tuition and fees (CTF) are a component of a couple's future childrearing cost. In Taiwan, the rapid development and availability of higher education has increased college enrollment to more than 80% of those willing to partake[3]. In fact, all students can pursue higher education if they have the desire and ability; higher education in Taiwan has become the norm, not the exception. Since this is the case, it is reasonable to assume that parents-to-be would consider CTF as part of their cost of bearing children. It is likely that this will affect their decision towards having children. In this regard, discovering the relationship between the cost of higher education and fertility is a worthwhile exercise as few studies have done so to date.

The primary purpose of this study, therefore, is to examine the influence of CTF on Taiwan's fertility rate. This study uses official panel data from 23 counties and cities over the period 1990–2001. Using the fixed-effect model described by Hsiao

[1] GFR is defined as births per thousand women between the ages of 15 and 49.

[2] Leete (1987) characterized post-demographic transition phase as the postponement of death, a conspicuous rise in the age at marriage, and an avoidance of births.

[3] In 2002, 80% of those willing to take college entrance examinations were enrolled for study at a university or college. There are more than 100,000 students in Taiwan willing to take college entrance examinations each year; most are third-year high school students.

(1995), this study will explore the quantitative effect of college tuition and fees on Taiwan's fertility trend.

This study is organized as follows: Section 2 illustrates the theoretical model and reviews the related literature. Section 3 describes the development of higher education in Taiwan. Methodology and data is introduced in Section 4, while Section 5 presents the results of our empirical analysis. Finally, some conclusions are drawn in Section 6.

Theoretical model and literature review

Since it is impossible to predict CTF 18 years from now (denoted as CTF_{18}^{e}), it is assumed that CTF_{18}^{e} is highly correlated with the current amount, CTF_0. According to Rational Expectations Theory, such an expectation is defined as the *best guess of the future*, or *the optimal forecast* that uses all available information. Since the only information people have is CTF_0 when they make a fertility decision, it is plausible to assume that people will use this available information to rationally expect future CTF. The theory of rational expectations then says that CTF_{18}^{e} is equal to:

$$\mathrm{CTF}_{18}^{e} = \mathrm{CTF}_0 + \varepsilon \text{ or } E(\mathrm{CTF}_{18}^{e}) = \mathrm{CTF}_0 \tag{1}$$

ε is the random error term, assumed to have zero mean to be independent of CTF_0, while E(.) denotes the expected value. That is, on average, ε equals zero and is independent of CTF_0.

Theoretical model

The simple theoretical 'model of fertility choice' provides a clear understanding of the CTF-Fertility relationship. Children are viewed as traditional commodities in the utility function, and it is assumed that all non-market time is spent exclusively on raising them. The child-bearer is assumed to be pursuing her maximum utility by choosing an optimal bundle of goods and children. Her utility, therefore, is a function of the goods consumed, X, and the number of children born, C. C is the number of live births, B, times the infant survival rate, γ. A relationship exists between the exposure to having children, i.e. birth control, and fertility. Thus the number of births is the exposure to risk, e, minus the number of times exposure is controlled, ρ[4].

With regard to budget constraints, it is assumed that the commodity price is one; the amount spent per child is the childrearing cost, P, plus CTF, and each child requires one unit of time. The total available time, T, is distributed between work and children. Given these parameters the utility-maximization problem is as follows:

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

[4] In Georgellis and Wall (1992), this birth control parameter ρ captures the degree of control that a woman has over the number of births.

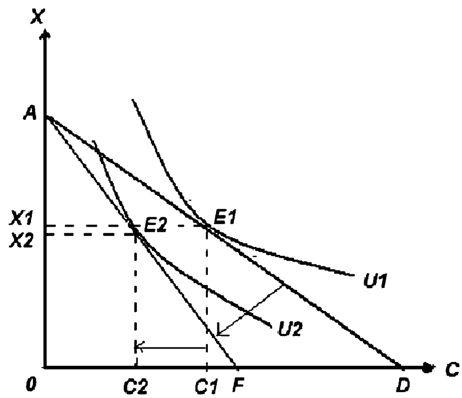

Fig. 1 The CTF and fertility decision

Here, Y and w represent non-labor income and the mother's market wage rate, respectively.

From (2), the demand for children is then obtained by using the demand of exposure to childbearing, e, minus the birth control parameter, ρ.

$$C = e(Y, w, \mathrm{CTF}, \rho, \gamma) - \rho. \tag{3}$$

In this way, CTF clearly plays a negative role in a family's fertility behavior since it represents a direct cost of having each child[5]. Ceteris paribus, CTF is an economic disincentive to a couple's demand for children.

This negative impact of CTF on the fertility decision is illustrated in Fig. 1. Assume there are two categories of goods that make a couple happy: Children, C, and the goods bundle X that can be bought with money. Before a rise in CTF, a couple's budget constraint is AD where the slope represents the total cost of childrearing (since the price of X is assumed to be 1) and the indifference curve is U_1. In order to maximize their utiity level, a couple will make their decision at point E_1 where the constraint meets the indifference curve, the tangent of AD and U_1. At this point, they will decide to have C_1 children and consume X_1 goods. After an increase in CTF, the new constraint is AF. Then the couple's maximum utility is E_2, having C_2 children. On this basis, this study proposes that higher college fees will discourage couples from having (more) children and, thereby, further reduce the fertility rate in Taiwan.

Literature on birth behavior

As mentioned earlier Becker (1960) and Schultz (1973) constructed the main theoretical approach to human fertility behavior, since then 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 & Weininger, 1973;

[5] In the U.S. 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) showed that the EITC has a positive influence on the decisions of low-income families to have their first child.

Blau & Robins, 1989; Mocan, 1990)[6]. Some studies have concluded that personal tax exemptions have a statistically positive correlation to fertility behavior in both time-series and panel data (e.g., Whittington, Alam & Peters, 1990; Georgellis & Wall, 1992; Gohmann & Ohsfeldt, 1994; Whittington, 1992; Whittington, 1993; Huang, 1998). Non-economic factors also have an influence on fertility behavior. Temperature, for example, has a significant influence on the timing of births (Seiver, 1985; Land & Cantor, 1983; Lam & Miron, 1996).

Similar empirical studies in Taiwan, Mueller and Cohn (1977), however, have failed to find a positive correlation between income and fertility even after considering attitude differentials[7]. Schultz (1988) found that Taiwan's family planning program is particularly effective in reducing birth rates in some specific regions[8].

Social and cultural factors also affect 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 Taiwan. Yen and Yen (1992) indicated a negative correlation to a woman's education level[9]. Liu (1995), however, said that the influence on fertility rate by socioeconomic factors is only minor, and that direct institutional measures are the best way to return fertility to a stable replacement level. On the other hand, Cheng and Nwachukwu (1997) demonstrated that education has no significant influence on fertility, contrary to several other studies.

Two recent studies investigate the effect of unemployment and tax exemptions on the fertility and conception rates. Huang (2002) demonstrated that a personal tax exemption has a statistically and significantly positive effect on GFR, while Huang (2003) found that the conception rate is negatively correlated to the unemployment rate.

The present analysis would be very difficult to conduct in a country like the U.S. since the expected future CTF would be impossible to predict[10]. It is thus that few research studies have shed light on this topic. In the following section this study describes Taiwan's educational development and the link between CTF and GFR.

The development of higher education in Taiwan

Education is a fundamental institution in any country and provides the key to its continued economic success and the well being of its residents. The 21st century belongs to the knowledge-based economy and it will be one of intense competition. Higher education in this sense is the foundation for national development and competitiveness. Though policymakers are often relegated to a supporting role in a

[6] Cain and Weininger (1973) proved that a woman's wage rate has a negative effect on the number of children she bears. 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 fertility behavior over the business cycle.

[7] Mueller and Cohn (1977) used Taiwan statistics from 1966.

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

[9] This conclusion comprises two issues: (1) the effect of the opportunity cost of a woman's time raising children and (2) the attitudinal effect.

[10] In the United States, CTF is not only different between public and private schools, but also differs among states. In addition, not every person is expected and is able to study at a college.

market economy, ensuring macroeconomic stability and the rule of law, education on the other hand, particularly higher education, does come under direct state control. For this reason, Taiwan's Ministry of Education (MOE) may be able to directly affect the fertility rate and so ameliorate population transition while simultaneously developing Taiwan's global competitiveness.

When the central government first moved to Taiwan from Mainland China in 1949, there was only one university (National Taiwan University) and three independent colleges with a student body of less than 5,000. The first private college was established in 1953. Private institutions now comprise over half of all institutions and have spurred the development of higher education as a whole. Later in 1974, the first vocational college of technology launched a new dual-track system of both academic and vocational studies. The New University Law enacted in 1994 gave universities autonomy and academic freedom[11].

The number of and students of higher education over the past several decades has been growing along with government policies. Table 1 shows the growth of both public and private institutions over the past several decades. In 1978, there were only

Table 1 Number of colleges and universities in Taiwan

Academic year	Private			Public			Total
	College	University	Subtotal	College	University	Subtotal	
1978	10	3	13	7	6	13	26
1979	10	3	13	5	8	13	26
1980	6	7	13	5	9	14	27
1981	6	7	13	5	9	14	27
1982	6	7	13	6	9	15	28
1983	6	7	13	6	9	15	28
1983	6	7	13	6	9	15	28
1985	6	7	13	6	9	15	28
1986	6	7	13	6	9	15	28
1987	7	7	14	16	9	25	39
1988	7	7	14	16	9	25	39
1989	7	8	15	13	13	26	41
1990	12	8	20	13	13	26	46
1991	14	8	22	15	13	28	50
1992	14	8	22	15	13	28	50
1993	15	8	23	15	13	28	51
1994	18	8	26	17	15	32	58
1995	18	8	26	18	16	34	60
1996	22	8	30	21	16	37	67
1997	19	18	37	21	20	41	78
1998	23	18	41	22	21	43	84
1999	36	23	59	25	21	46	105
2000	50	28	78	24	25	49	127
2001	55	30	85	23	27	50	135
2002	55	34	89	23	27	40	129
2003	54	37	91	21	30	51	142

Source: Department of Higher Education, Ministry of Education, Taiwan.

[11] The current higher education system consists of research universities, comprehensive universities, and technological universities. While the functions of the first two include teaching, research, service, and extension, with an emphasis on research and teaching, the functions of the later emphasize technological education and research.

26 colleges and universities including 13 private schools. From 1978 to 1986 this number grew very slowly and the student body totaled 19,800. In the mid-1980's the number of Taiwan's educational institutions increased rapidly. By 2000, there were 127 institutions with 647,000 students, an increase of 2.27 times. In 2003, there were 142 universities (including 51 public universities and 91 private universities) with more than 780,000 students. MOE reports that the college enrollment rate for 2003 was 83.22%!

This rapid development of the institutions of higher learning and their high enrollment rate has caused some serious financial problems. According to Taiwan's constitution, outlays for education should not be less than 15% of total government expenditure. However, the government has not had the budget to apply this rule strictly. Government funds earmarked for education have fallen short of that mark or have been diverted to other programs. MOE reports that the total collegiate budget was US$5.7 billion in 2000 and slightly increased to US$5.9 billion in 2003. Government subsidizes per student per year in a public university or college were US$7,000 in 1993, but declined to US$5,400 in 2002. To create more financial independence among national universities, the government launched the ‘‘University Fund'' in 1995. This plan called for universities to fund part of their programs directly and, thereby, reduce their reliance on government. Hence, from 1999, each university implemented its own fund-raising plan.

Table 2 lists tuition and fees for both public and private schools from 1989 to 2003. This official information provided by MOE is the weighted average by student population in each university/college[12]. It shows that the average tuition and fee per semester for public versus private schools in 1989 was US$340 and US$1,050, respectively, and increased to US$826 and US$1,512 in 2003. The CTF growth rate for public schools was 216.23%, whereas private schools grew by 87.65% over this period. This differential rate of growth has narrowed the gap in tuition and fees between public and private schools. Measured as a ratio, this tuition gap fell from 3.09 to only 1.83 in 2003[13].

This study calculates the weighted CTF as follows.

Table 2 Average CTF per semester per student in Taiwan

Academic Year	Public (US$)	Private (US$)	Private/Public
1989	340.25 (8.36%)	1050.09 (9.33%)	3.09
1992	505.07 (14.42%)	1387.36 (5.74%)	2.75
1995	644.20 (12%)	1739.07 (4%)	2.70
1998	691.38 (10.95%)	1494.59 (5.48%)	2.16
2001	801.92 (4.34%)	1538.36 (0.04%)	1.92
2003	825.62 (2.05%)	1512.05 (0.09%)	1.83

Source: Ministry of Education, Republic of China, Taiwan

Note: 1. Numbers in parentheses are growth rates. 2. The values are in current dollars

[12] Tuition varies across departments and schools in any particular university or college. For example, the tuition fees are higher in the College of Medicine than for other colleges.

[13] In order to ease the burden on students and to seek a balance between public and private schools, the Ministry of Education has substantially increased assistance to private schools in recent years.

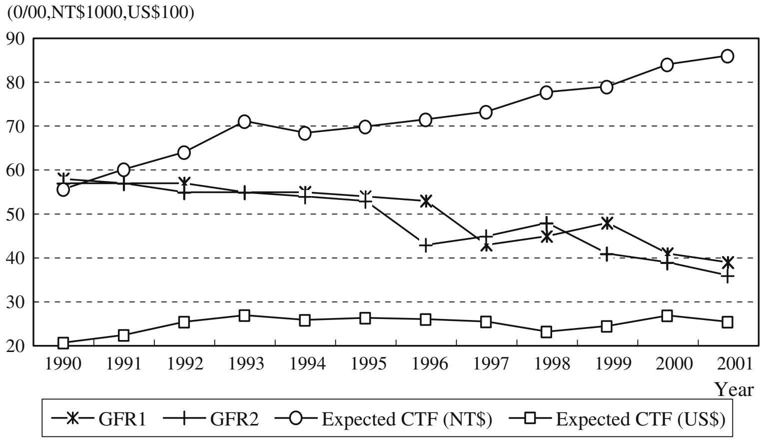

Fig. 2 The GFR and real CTF in Taiwan (1990–2001)

$$\mathrm{CTF}_t = P_t^N \times \mathrm{CTF}_t^N + (1 - P_t^N) \times \mathrm{CTF}_t^P. \qquad (4)$$

In Eq. (4), CTF_t is the weighted college tuition and fees in year t, CTF_N and CTF_P are the fees for national (public) and private schools, respectively[14]. Term P_t^N represents the proportion of students studying in national schools in year t. The weighted real CTF is calculated in 2001 dollars.

Figure 2 shows real CTF and GFR from 1990 to 2001, GFR is lagged by one and two years denoted by GFR1 and GFR2, respectively. From the graph it is observed that while real CTF increases dramatically, fertility behavior declines suggesting an inverse correlation between the two. This study will explore this relationship in the next section.

Empirical model and data description

Data sources include the Department of Statistics in the Ministry of the Interior, the Ministry of Education, and the Department of Health of the Executive Yuan, Taiwan. This study uses cross sectional time-series data (generally called panel data) by region to measure the responsiveness of GFR to changing socioeconomic factors, particularly to changes in CTF. This regional panel data covers 16 counties and seven cities in Taiwan[15] from 1990 to 2001, the longest contiguous panel available. Thus, the number of observations used in the regression models is 276 (23 regions by 12 years). This is advantageous since the abundance of data points allows us to use a

[14] It is true that any changes in the weight of private schools will change the weighted CTF. The weights of both private and public schools are determined by Taiwan's Ministry of Education and can be treated as exogenous.

[15] The 16 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.

fixed-effects model with an intercept variable[16]. Using this model this study can consider heterogeneity across the regions and through time while varying the intercept to account for omitted independent variables[17]. The variables omitted in our research were time-invariant by region such as cultural attributes. Hence, this study focuses on regional specific effects.

The fixed-effects model for fertility is estimated below.

$$\begin{aligned}\mathrm{GFR}_{i,t+k} = {} & \alpha_i + \beta_1 \times \mathrm{Log}(\mathrm{CTF}_t) + \beta_2 \times \mathrm{Log}(\mathrm{INCOME}_{i,t}) \\ & + \beta_3 \times \mathrm{WINCOME}_{i,t} + \beta_4 \times \mathrm{INFANT}_{i,t} + \beta_5 \times \mathrm{UR}_{i,t} \\ & + \beta_6 \times \mathrm{WCOLLE}_{i,t} + \beta_7 \times \mathrm{WA2539}_{i,t} + \beta_8 \times \mathrm{SUBSIDY}_{i,t} \\ & + \beta_9 \times \mathrm{Y98} + u_{i,t+1}\end{aligned} \tag{5}$$

Here, i = 1, 2, ..., 23, the regions; t = 1990, 1991, ..., 2001, the years; k = 1 or 2, the lag parameter; and $u_{i,t}$ is a well behaved random error variable[18]. The regional specific constant term, $\alpha_{i,}$ captures differences across regional and time units. The Lagrange Multiplier (LM) test, devised by Breusch and Pagan (1980), was used to examine region specific effects[19].

The dependent variable, GFR, is defined as births per 1,000 women aged between 15 and 49. The advantage of GFR over crude birthrate is that it is less sensitive to changes in this demographic (Whittington, Alam & Peters, 1990)[20]. A time lag occurs between receiving CTF information and making the decision to have children. A time lag also occurs between making the decision and the actual birth, given the obvious biological constraints. Therefore, GFR must be lagged. Since some independent variables are potentially endogenous such as working status, working hours, and conception, an estimation of the fertility equation using a one-year lagged form may create problems. Thus, to avoid certain econometric issues[21], it is necessary to estimate the fertility equation in a two-year lagged form as well.

As mentioned in Section 2.1, the explanatory variable, CTF, is calculated in Eq. (4). Since an increase in CTF tends to discourage the demand for children, this study

[16] Another variable-intercept model called the random-effects model was also considered for this study. According to Hill, Griffiths and Judge (2001), the random-effects model is very useful when the cross-sectional units are randomly chosen from a larger population of regions. Since all the regions were available for this study, we could use the fixed-effects model instead. Otherwise, the Hausman test proposed by Hausman (1978), we could also be used to test whether the region specific effects are correlated with other regressors in the model.

[17] Intercept variables come in three flavors: individual time-invariant, period individual-invariant, and individual time-varying. As discussed in Hsiao (1995), running a least-squares regression with pooling data may lead to a false inference when the hypothesis is rejected for the regression parameters that take a value common in all cross-sectional units for all time periods.

[18] That is to say *ui,t* is independently and identically distributed with mean zero and variance σu2.

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

[20] Since the theoretical argument is made in terms of TFR, the shift to GFR cannot be analytically ignored. Though TFR may not change when a greater proportion of women are in their child-bearing years, GFR will be higher. GFR's decline can be due to the aging of the child-bearing demographic if births are concentrated in the early years. The authors appreciate a reviewer's advice in this regard.

[21] Because some pregnancies may not go to term due to premature births, miscarriages, abortions, or stillbirths, this study focuses the sub-sample of live births only. Indeed, as Cigno (1994) pointed out, this uncertainty must be taken into account in a couple's decision-making. However, since this uncertainty is random, ignoring it will not cause the introduction of a biased estimator.

expects the coefficient of CTF to be negative. Additional explanatory variables include economic and demographic factors that can affect both the demand for and supply of children. Family income (INCOME) is measured as the difference between average family income and average spousal earnings by region in order to isolate the impact a woman's earnings have on fertility. However, explaining the sign of the family income coefficient should be done very carefully. Any conclusion as to whether children are normal or inferior goods when using regional panel data rather than family-level data may be erroneous. With respect to woman's earnings, since a woman's earnings are treated as a time cost, WINCOME is included as the opportunity cost of childrearing[22]. This study would expect the regional GFR to be lower as WINCOME increases.

According to Whittington, Alam and Peters (1990), the infant mortality rate (INFANT) has two effects on fertility rate: (1) the replacement effect, if the infant mortality rate increases, the fertility rate will too; and (2) 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 brings about a lower fertility rate.

The unemployment rate (UR) has also been shown to influence fertility behavior. Mocan (1990) suggested that both male and female unemployment rates have a negative effect on fertility: fertility is pro-cyclical in bivariate VAR models, while counter-cyclical in multivariate VAR models. The unemployment rate in Taiwan has a negative affect on the fertility rate (Huang, 2002, 2003). So this study can expect the sign of coefficient of UR to be negative.

Moreover, as Cain and Weininger (1973) demonstrated that female education (WCOLLE) and male earnings both have an inverse effect on fertility. Hence, this study will expect the influence of WCOLLE to be negative as well. A woman's age may also play an important role in her fertility choices. In the regression model, WA2539, is used as an independent variable designating the ratio of the demographic aged 25–39 to all women aged 15 or above. A region with a higher ratio for WA2539 is more likely to have a higher fertility rate.

Recently childrearing support policies have been adopted across various regions of Taiwan. A small and one-shot subsidy for couples to have another child is paid in cash and may be as much as US$500. Though this direct subsidy payment (SUBSIDY) may have a positive effect on the fertility rate, it is likely small or insignificant. Since CTF increases over time, Y98 is used as a dummy variable for 1998 onward instead of a variable for consecutive years to avoid collinearity. Figure 2 shows the fertility rate after 1997 to be much lower than it was, therefore, this study expects the coefficient of Y98 to be negative.

To control for price fluctuation, the following were deflated by CPI, the consumer price index: CTF, regional average family income, and the regional average of a

[22] The use of the average woman's earnings instead of average woman's wage rate as the opportunity cost of child-rearing comes about as a result of the unavailability of the average working hours and the average wages for women by region.

woman's annual earnings have been, and in logarithmic form[23]. Table 3 summarizes these variables definitions, statistics, and expected sign[24].

Empirical estimation

This study conducts four specifications of the fertility equation to analyze the impact of CTF on GFR. In Table 4, Models 1 and 2 have one-year lagged fertility equation forms and Models 3 and 4 have two-year lagged forms. Models 1 and 3 use the general unemployment rate, whereas Models 2 and 4 use the male and female unemployment rates in order to compare the influence of the unemployment rate for different gender on GFR.

The *F* test in Table 4 concludes decisively that there are regional specific effects and indicates that the fixed-effects approach is better than the classical approach. Since all specifications have a heteroskedasticity problem, the corrected covariance matrix proposed by White (1980) is used. That is, the usual set of OLS results is

Table 3 Descriptions and statistics of the variables

Variables	Descriptions	Mean	Standard deviation	Expected sign
GFR_{t+1}	General fertility rate of the following year: births per 1,000 women aged 15–49 (‰).	55.232	9.733	
GFR_{t+2}	General fertility rate two years later: births per 1,000 women aged 15–49 (‰).	55.232	9.733	
CTF_t	Real weighted average of real college tuition and fees per semester (CPI = 100 in 1996) (NT$/per year).	71,797.1	8,740.34	–
$INCOME_t$	Real average of real family income net of woman's earnings per household (CPI = 100 in 1996) (NT$/per year).	401,086	75,378.2	?
$WINCOME_t$	Real average of real woman's earnings (CPI = 100 in 1996) (NT$/per year).	188,498.9	41,980.03	–
$INFANT_t$	Ratio of deaths for under 1 year old babies to number of live births	6.184	1.513	?
UR_t	Regional annual unemployment rate (%).	2.354	1.051	–
$UR^M{}_t$	Regional annual male unemployment rate (%).	2.488	1.260	–
$UR^F{}_t$	Regional annual female unemployment rate (%).	2.155	0.847	–
$WCOLLE_t$	Proportion of women's educational level being college or above (%).	8.313	4.411	–
WA2539	Proportion of women's age between 25–39 to all women aged 15 or above (%).	33.429	3.528	+
$SUBSIDY_t$	Real regional subsidy for each birth (CPI = 100 in 1996) (NT$/per year).	376.841	1,659.48	+
Y98	=1 if year is 1998 and afterward, =0 otherwise.	0.333	0.472	–

Source: Same as in Table 2

[23] Since Taiwan is a small country its CPI might not vary significantly across counties/cities. Also, because regional CPI data is not available, using the national CPI to deflate nominal variables is our best estimate.

[24] Since data is not available to create some variables, their influence is captured in parameter α_i of Eq. (5). These variables include: the availability of daycare nurseries or nursery schools, the proportion of aboriginal people, and the proportion of contraception use.

Table 4 Estimation results of fixed-effect models

	GFR_{t+1} as Dependent variable		GFR_{t+2} as Dependent variable	
	Model 1	Model 2	Model 3	Model 4
$\log(\mathrm{CTF}_t)$	–11.25***(2.25)	–11.31***(2.28)	–15.48***(2.32)	–15.62***(2.33)
$\log(\mathrm{INCOME}_t)$	0.34(0.44)	0.34(0.44)	–1.04**(0.49)	–1.06**(0.50)
$\log(\mathrm{WINCOME}_t)$	–1.10***(0.41)	–1.10***(0.40)	0.03(0.43)	0.03(0.44)
INFANT_t	–0.09(0.13)	–0.10(0.13)	–0.02(0.17)	–0.02(0.17)
UR_t	–1.90***(0.25)		–2.44***(0.28)	
$\mathrm{UR}^M{}_t$		–1.33***(0.29)		–1.64***(0.34)
$\mathrm{UR}^F{}_t$		–0.52*(0.31)		–0.75**(0.30)
WCOLLE_t	–0.13(0.10)	–0.12(0.10)	–0.21*(0.13)	–0.20(0.13)
WA2539	–0.08(0.22)	–0.10(0.22)	–0.04(0.23)	–0.06(0.23)
$\mathrm{SUBSIDY}_t$	$1.6(10^{-4}(1.2(10^{-4})$	$1.8(10^{-4}(1.2(10^{-4})$	$1.2(10^{-4}(1.6(10^{-4})$	$1.4(10^{-4}(1.6(10^{-4})$
Y98	–7.39***(0.56)	–7.34***(0.59)	–6.52***(0.59)	–6.49***(0.61)
Observations	276	276	276	276
R^2	0.94	0.94	0.94	0.94
Adjusted R^2	0.94	0.94	0.93	0.93
F-Statistic	130.80***	126.15***	121.35***	116.76***
Fixed-effect versus classical: F-test	34.78***	34.11***	27.03***	26.39***
RESET	2.6×10^{-7}	5.5×10^{-4}	1.8×10^{-7}	9.2×10^{-4}

Note: 1. *, **, and *** indicate that the null hypotheses are rejected at 10%, 5%, and 1% significant level, respectively. 2. Numbers in parentheses are standard errors

given, but with a revised and more robust covariance matrix. This study conducted RESET, the Regression Specific Error Test[25], to determine whether this study has omitted important variables, chosen the correct functional form, or violated the assumptions of the multiple regression models. Table 4 shows the results of RESET and it concludes that the null hypothesis cannot be rejected[26], implying that the test has not been able to detect any misspecification (such as omitted variables)[27]. Table 4 also reports the estimations of the four fixed-effects models taking heteroskedasticity into account.

Estimation results

According to Table 4, the coefficient of CTF is statistically significant and negative in all specifications. Hence the study can safely conclude that a negative relationship

[25] Using Hill, Griffiths and Judge (2001), the RESET test was conducted to detect omitted variables and verify functional form. The RESET process adds a square term to the predicted values of the dependent variable of each regression model. It can be written as follows: $Y_t = \beta_1 + \beta_2 X_{t2} + \beta_3 X_{t3} + \gamma \hat{Y}_t^2 + e_t$. The test for misspecification is H_0: $\gamma = 0$ vs. H_1: $\gamma \neq 0$. Failure to reject *H0* means that the test did not detect a misspecification.

[26] The RESET result cannot totally exclude the possibility that some variables may have been omitted. It is a test for non-linearity and tests for nonlinear transforms in the specified independent variables. The authors appreciate a *JFEI* reviewer for pointing this out.

[27] In fact, omitting regional price information such as average housing costs, average childcare costs, etc. in a regression model might cause a biased estimation. But since regional price information is not available, the authors acknowledge the omission. Unlike the U.S., Taiwan is a small country and the variance of regional prices may not have a significant effect on the result. Regional prices may also be correlated to other variables reflecting economic development such as average family income. Their influence will be picked up by the regional-specific effect, αi, since childcare costs are associated with the regional culture characteristic.

between CTF and fertility does exist in Taiwan. This finding is very robust and consistent whether a one-year or two-year lagged form is used and whether the general unemployment rate or the two genders' unemployment rate is used. With respect to the magnitude of the influence of CTF on GFR, the marginal effect is in the range from –11.25‰ to 15.62‰—that is, a 1% increase in CTF will decrease the number of births by 67,000–98,000.

There are a number of other factors in Table 4 that significantly affect the demand for children, influences that are consistent with our expectations from Table 3. The unemployment rate demonstrably has a negative impact on fertility. Models 1 and 3 show unemployment rates exert a significant negative influence on GFR, which is consistent with Huang (2002, 2003). The same is true after substituting both the male and female unemployment rates for the general unemployment rate. Models 2 and 4 indicate that both unemployment rates taken together have a negative influence on GFR. Moreover, both model specifications suggest that the male unemployment rate plays a more significant role in fertility decisions than the female unemployment rate, most likely because males are the primary provider for the family. The dummy variable, *Y98*, also has the expected negative coefficient, which is consistent with the actual phenomena over time. This recent decline in GFR is likely due to a decline in the preference for having children.

The regional average family income and a woman's college education have no significant effect on fertility rate except in Model 3. The regional average of a woman's earnings has an indecisive effect on GFR and only becomes significantly negative when using a two-year lagged form[28], i.e. Models 1 and 2. It is not surprising that neither family income nor a woman's earnings are significant since that is also the conclusion of existing literature[29]. Hence, regional GFR is determined by factors other than family income and a woman's earnings. Interestingly, the preference for children of highly-educated women is the same as less educated women. Other factors, such as infant mortality, a woman's age, and childrearing subsidies, seem to play no important role on Taiwan's regional GFRs.

With respect to the estimated regional-specific effect, α_i, the estimated results are shown in Table 5. After controlling other factors, the autonomous fertility rate is highest in Hsinchu County followed by Chiayi County. In addition to these two counties, Yunlin County, Miaoli County, and Taitung County are listed as the top five autonomous fertility rates. As mentioned before, the regional-specific effect, α_i, captures factors other than those included in the regression, such as culture, living style, environment, temperature, preference, and custom.

The five regions with the lowest autonomous fertility rate are Kaohsiung City, Taipei City, Tainan City, Chiayi City, and Taipei County. The first two are municipalities directly under the jurisdiction of the Central Government, and the third and fourth are under the jurisdiction of the Provincial Government. Taipei County is the largest county by population in Taiwan. These regions all have a common feature,

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28 Another approach might be to consider the influence of regional average family income over regional GFR across income groups. However, it would be difficult to calculate since it is hard to define the high and low-income regions and if a dummy variable is used in the fixed-effects model, then a collinearity problem will arise.

29 For example, 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.

Table 5 Regional-specific effects α

Regions	Model 1		Model 2		Model 3		Model 4	
	coefficient	*t*-ratio	coefficient	*t*-ratio	coefficient	*t*-ratio	coefficient	*t*-ratio
Taipei County	193.1 (19)	6.2	194.6 (19)	6.1	241.9 (20)	7.8	244.3 (20)	7.8
Yilan County	203.7 (7)	6.7	205.0 (7)	6.6	252.4 (7)	8.3	254.7 (7)	8.3
Taoyuan County	201.2 (10)	6.4	202.7 (10)	6.4	250.0 (12)	8.0	252.4 (12)	8.1
Hsinchu County	213.6 (1)	7.0	215.0 (1)	6.9	262.0 (1)	8.5	264.4 (1)	8.6
Miaoli County	206.6 (4)	6.8	207.9 (4)	6.8	255.1 (4)	8.4	257.4 (4)	8.5
Taichung County	201.2 (11)	6.5	202.6 (11)	6.5	250.1 (11)	8.1	252.4 (11)	8.1
Changhua County	202.6 (9)	6.7	203.9 (9)	6.6	251.4 (9)	8.3	253.6 (9)	8.3
Nantou County	204.9 (6)	6.8	206.2 (6)	6.7	253.3 (6)	8.3	255.6 (6)	8.4
Yunlin County	207.0 (3)	7.0	208.2 (3)	6.9	256.2 (3)	8.6	258.4 (3)	8.6
Chiayi County	208.6 (2)	7.0	209.9 (2)	6.9	257.4 (2)	8.6	259.7 (2)	8.6
Tainan County	197.7 (16)	6.5	199.1 (15)	6.5	246.8 (16)	8.1	249.2 (16)	8.2
Kaohsiung County	198.0 (14)	6.4	199.4 (14)	6.4	247.2 (14)	8.1	249.6 (14)	8.1
Pingtung County	199.5 (13)	6.6	200.8 (13)	6.5	248.1 (13)	8.2	250.4 (13)	8.2
Taitung County	205.7 (5)	6.8	207.0 (5)	6.8	254.6 (5)	8.4	256.9 (5)	8.5
Hualien County	202.9 (8)	6.7	204.2 (8)	6.6	251.8 (8)	8.3	254.1 (8)	8.3
Penghu County	197.8 (15)	6.7	199.0 (16)	6.6	247.1 (15)	8.3	249.3 (15)	8.3
Keelung City	196.8 (18)	6.4	198.1 (18)	6.3	246.1 (18)	8.0	248.4 (18)	8.0
Hsinchu City	201.1 (12)	6.5	202.6 (12)	6.5	250.7 (10)	8.1	253.1 (10)	8.2
Taichung City	196.9 (17)	6.2	198.3 (17)	6.2	246.5 (17)	7.9	248.9 (17)	7.9
Chiayi City	193.0 (20)	6.3	194.4 (20)	6.3	242.8 (19)	8.0	245.2 (19)	8.0
Tainan City	190.9 (21)	6.1	192.3 (21)	6.1	240.6 (21)	7.8	243.0 (21)	7.8
Taipei City	189.7 (22)	6.1	191.0 (22)	6.1	240.5 (22)	7.8	242.7 (22)	7.9
Kaohsiung City	189.5 (23)	6.1	190.8 (23)	6.1	239.4 (23)	7.7	241.7 (23)	7.8

Note: Numbers in parentheses are ranks

prosperity, which likely causes different preferences toward fertility, life style and culture thereby reducing the propensity to have children.

Overall, the regions with highest and lowest autonomous fertility rate are the same across different model specifications and, therefore, these conclusions seem to be both consistent and robust.

Policy analysis

If the Central Government decided to reduce tuition fees by 1%, it would need to compensate the Ministry of Education for the difference in order to maintain their budget. MOE, in turn, would pass the reduction on to students. The government's total cost for such an intervention in any given year would be the real CTF times the number of college students. Since it has been found that a reduction in CTF will induce an increase in GFR, this study considers a 1% reduction in CTF as the price Taiwan's government must pay to stimulate population growth. Table 6, then, presents the Central Government's cost per additional birth after a 1% decrease in real CTF. It is seen from the table that a 1% decrease in real CTF amounts to US$8.65 million in 1995 and increases over time to US$17.95 million in 2001. The induced increase in births caused a by 1% decrease in real CTF can be calculated using the marginal effect of log (CTF) in the various model specifications. Hence, in the one-year lagged Models 1 and 2 for 1995, the increase in births is 67,570 and 67,930 for

Table 6 Cost pER additional birth after a 1% decrease in real CTF in Taiwan

Items			1995	1996	1997	1998	1999	2000	2001
Total college students[1] (1000 people)			314.50	337.84	373.70	409.71	470.03	564.06	677.17
Total reduction in real CTF[2] (US$ million)			8.65	9.16	9.95	9.91	11.98	15.80	17.95
Total increase in birth[3] (1000 birth)	Year+1	Model 1	67.57	68.98	70.35	71.02	72.00	70.76	71.18
		Model 2	67.93	69.35	70.72	71.4	72.38	71.13	71.56
	Year +2	Model 3	94.92	96.80	97.72	99.07	97.36	97.94	97.80
		Model 4	95.78	97.67	98.60	99.97	98.24	98.83	98.69
Cost of Per additional birth in real value[4] (US$ per birth)	Year+1	Model 1	128.02	132.83	141.44	139.59	166.37	223.36	252.23
		Model 2	127.34	132.12	140.68	138.85	165.49	222.17	250.89
	Year +2	Model 3	91.13	94.66	101.83	100.06	123.03	161.35	183.57
		Model 4	90.31	93.81	100.91	99.17	121.93	159.90	181.92
Exchange rate US$1 = NT$			26.48	27.46	28.66	33.44	32.27	31.23	33.80

Note: [1] Data provided by Department of Higher Education, Ministry of Education, Taiwan. [2] The values are in 2001 dollars and the exchange rates of each year are adopted. The total reduction in real CTF in a specific year is calculated as follows: (real CTF of Private School) (1% (Total Students in Private Schools + (real CTF of Public School) (1% (Total Students in Public Schools. The CTF of private and public schools is provided by the Department of Higher Education, Ministry of Education, Taiwan, and available upon request. [3] Total increase in births in a specific year = (Total female aged 15–49) (Marginal effect of log(CTF)/1,000. [4] Cost Per Additional Birth = (The total reduction in real CTF)/(Total increase in birth)

the next year, 1996, respectively[30]. In the two-year lagged Models 3 and 4 for 1995, the increase in births is 94,920 and 95,780 for 1997, respectively.

It is reasonable that the two-year lagged scenarios create more births since couple's will have more information for making fertility decisions and a longer period to adjust their fertility behavior. The two-year lagged form can also sidestep potential endogenity problems, which could bias the estimation. Finally, a 1% decrease in real CTF in 2001 will encourage people to have 71,180 and 71,560 more births in 2002 and 97,800 and 98,690 more births in 2003 in Models 1, 2, 3, and 4, respectively.

The cost per additional birth in the one-year lagged models ranged from US$127.34 to US$252.23, while in the two-year lagged scenarios and the cost ranged from US$90.31 to US$183.57, roughly 29% lower than in the one-year lagged cases.

Concluding remarks

This study investigates the influence of college tuition and fees (CTF) on fertility behavior as a mechanism to induce population growth. Taiwan's education policy is uniform and applies to all colleges and universities. The Ministry of Education sets tuition and fees and they are strictly applied. Government policy over the last two decades has created a dramatic increase in both the number of post-secondary institutions and students. In fact, the college enrollment rate has reached an all time

[30] For example, in 1995 the total number of females aged 15–49 is 6,005,870 and the marginal effect of log(CTF*t*) in Model 1 is –11.25‰. Therefore, a 1% decrease in CTF will cause an increase of 67,570 (11.25‰ × 6,005,870) in the following year, 1996.

record 83.22% in 2003! This rate could approach 100% in the near future since the access to and expectation for post-secondary education in Taiwan is almost universal. Given this and the MOE's consistency in tuition policy, the calculation of expected CTF and its influence on fertility decisions is possible.

Using a fixed-effect regression model with various specifications of the fertility equation on contiguous panel data for the period 1990 to 2001, this study has determined of that CTF has a significantly negative influence on regional GFRs in Taiwan. Its marginal impact is greater in the two-year lagged scenarios than that in the one-year lagged form. In addition, unemployment rates also have a negative impact on fertility though the male rate plays a greater role in the fertility decision than the female rate. This study assumes that declining GFR in Taiwan is linked to a couple's marginal utility, or preference, for having children. Finally, this study calculates the cost in terms of CTF to the Central Government to induce population growth. For a 1% decrease in real CTF the cost to the government, and tax payers at large, for each additional child will range from US$90.31 to US$252.23 depending on the years considered and the model specifications.

It is worth noting that countries with aging populations have a number of options for dealing with this issue. These may include increasing the age thresholds for collecting retirement benefits (as the U.S. has done with Social Security), promoting public health measures that reduce health care costs, or relaxing immigration policies. However, Taiwan's government favors the use of fertility policies rather than such methods. For example, one official in 1999 suggested the use of a personal tax exemption to encourage Taiwanese families to have a third child to address Taiwan's aging problem[31]. In 2002, Taiwan's government also proposed to pay US$1,000 to US$1,600 for having two or more children. Regions such as Hsinchu City, Miaoli County, Hsinchu County, Tainan City, Tainan County, and Taitung County have offered a cash subsidy to families with more than one child. The cost of all such fertility enhancing programs in Taiwan is more than US$3 million, which unfortunately, probably has had very little on GFR as this study shows.

A recent public opinion poll conducted by legislators confirms that couples care about the cost of childrearing and that lower education costs would help. Therefore, based on the results of our study, should the Taiwan government prefer to use fertility policies instead of other prescriptions to mitigate population transition, then lowering college tuition and fees will be its best approach. In the alternative, should college tuition and fees continue to rise, it will dissuade stable population growth and likely create the onset of post-demographic transition with its attendant social costs.

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[31] This official was the Chairperson of the Manpower Planning Department of the Council for Economic Planning and Development (CEPD), Taiwan. However, members of the Ministry of Finance have since rebuffed this suggestion of its heavy impact on tax revenue.

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