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Education, Married Women's Participation Rate, Fertility and Economic Growth

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We construct a model, via educational expenditure, linking female labor supply to fertility and economic growth. Our paper includes three main themes. First, increases in parental time of teaching at home and educational expenditure lead to an increase in the level of human capital stock. Both home education and school education are inputs of the human capital production function. Second, the rising opportunity cost of having children discourages parental demand for children and encourages married women's participation. Finally, more investments in children's human capital result in a higher growth rate. Our model closely follows the process of demographic transition. In the developed stage, an economy with a high rate of educational expenditure has a low fertility rate, high female participation rate and perpetual growth. Our model is empirically able to explain the case of Taiwan's growth experience.

I. Introduction

Since Malthus (1798), population has long been recognized as a factor in economic development. As women compose around half the population, their contribution to economic development is evidenced by their trend of labor force participation in the histories of developed economies. When the labor force participation rate of a nation increases, the real GNP per capita also rises. The increase in the labor force participation rate mostly comes from an increase in the participation of married women. For example, from 1920 onwards, the labor force participation of married women in the United States climbed from 31.8% in 1960 to 40.8% in 1980,[1] while the real GNP per capita was $10,969 in 1960 and $16,790 in 1980.

The impressive relationship between human reproduction and women's work activity in an economy has been explored theoretically and empirically. Standing (1983) indicated that early research admitted that fertility was inversely related to women's labor force participation.

Namely, in advanced countries the high level of female participation encouraged low fertility. In low-income countries, due to few work opportunities and the low cost of childbearing, a high level of fertility has existed with low female participation. Recent

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1. The data comes from the Vital Statistics of the U.S. Department of Health and Human Services.

research found women who work can afford a larger number of children. Mincer (1985) concluded that the interrelationships between fertility and female labor force participation may be affected by other variables, notably by the process of economic growth. Especially important in this process are the growth of real wage, education, and urbanization.

This paper constructs a mechanism to show how the female participation rate contributes to economic growth. It combines a model of the household's fertility/labor supply choices with a growth model in which fertility and economic growth are endogenously determined. This study's main issue is how the female labor supply, through the proportion of educational expenditure, affects the accumulation of human capital, the level of fertility, and growth. It also shows how an underdeveloped economy can increase its growth rate by raising the educational expenditure.

Some studies of female labor supply and growth have focused on various mechanisms by which the two variables are related. Goldin (1986) considered female labor force as one of the long-term factors in American economic growth. The paper followed the neoclassical Solow model by decomposing the source of growth in total production into the growth in different inputs. They concluded that should the female labor force have not expanded over 1890-1980, the national income per capita would probably have been at least 14% lower than it actually was.

Galor and Weil (1996) explored another mechanism. Their main concern was with how growth, via change in women's relative wage, affected household decisions about fertility and female labor force participation, and how these decisions fed back through the production mechanism to affect output growth. They found that an increase in capital per worker raises women's relative wage, since capital is more complementary to women's labor input than to men's. Increasing women's relative wage reduces fertility, but raises women's participation. Furthermore, lower fertility raises the level of capital per capita and output per capita. The increasing growths in capital and output lead to a rapid decline in fertility, but to an increase in female labor supply.

In this paper we present a different mechanism linking female labor supply, fertility and growth. First, the production function of human capital has two inputs. One is parental time of teaching at home and the other is the educational expenditure. The more time is spent teaching at home, or the educational expenditure, the higher is the level of human capital accumulation. Second, the level of time cost or monetary cost of children will affect parent's demand for children, and the decision of the mother to work. Finally, the accumulation of human capital affects economic growth. More investment in children's human capital results in a higher growth rate.

Our model's rationale that human capital accumulated through parental time of teaching at home or educational expenditure refers to those studies by Hill and Stafford (1974) and Leibowitz (1977). They showed that those variables relating to family background deeply affect the stock of children's human capital, notably, the quantity of time and goods devoted by parents. For pre-school children, the more time mothers spend with them will improve their verbal ability. When children grow up, they spend more time in school, and parental financial support becomes more important than time. High-income parents spend more money on children's education, and mostly their children have a better achievement. The evidences above imply that both parental time and expenditure contribute to the investment in children's human capital. From the empirical data of Taiwan, the proportion of household income spent on education increased from 4.17% in 1972 to 5.72% in 1996.[2] The percentage of population over six years old who completed secondary school was 13.96% in 1972 and climbed to 46.38% in 1996.[3]

Our model's other theme focuses on the interrelationship between children's quality and quantity and mothers' working time. Mincer (1962) demonstrated that due to the income effect, given her husband's income, if a wife expects an increase in wage rate, she will decrease any market activity. On the other hand, because of the substitution effect, when the opportunity cost of leisure increases, the mother will increase her market activity. In our model, other things being equal, when the educational expenditure rises, mothers expect a decline in their consumption, and they will increase hours of work to finance the extra expense. Moreover, as the cost of schooling increases, mothers will spend more time to teach their children at home. Therefore, mothers' hours of work decrease. Mothers' decision on work then depends on which effect dominates the other.

The motive for having children in our model is pure altruism. Both quantity and quality of children affect parent's utility. In a developed economy, when parents want to raise a high-quality child, a mother will consider to spend more time teaching children at home, or disburse more money in school education. Becker and Lewis (1973) indicated that since the cost of having an additional child increases, the number of children goes down. In an advanced economy, the income effect of the educational expenditure on mothers' hours of work dominates the substitution effect. A higher educational expenditure leads to low fertility and high female participation.

The final theme of our model follows the perspective of the "new growth" theory. Most "endogenous growth" theories emphasize that human capital accumulation provides a powerful engine in economic growth. We use both mothers' time teaching at home and educational expenditure as inputs of the human capital production. An increase in the educational expenditure accelerates economic growth. In addition, we follow Becker, Murphy and Tamura (1990) (BMT, hereafter) and Ehrlich and Lui (1991) (EL, hereafter) to endogenize population growth. They obtained that a high level of human capital has a higher rate of return to human capital. Thus, economies with high human capital will have few children and invest more human capital in each child. Those with little human capital do the opposite. A similar result can be found in our paper.

When we consider the proportion of educational expenditure as a policy, we explore whether an increase in the proportion of educational expenditure will raise the stock of children's human capital. When the prices of children go up, parental demand for children goes down. Higher educational expenses and fewer children encourage mothers' participation in work activity. The rise in mothers' labor force participation and household income raises the investment in children's human capital. This further discourages fertility and increases economic growth.

Our model also reveals part of a demographic transition. When a country with a small

2. The figure is calculated from the Report on the Survey of Family Income and Expenditure, Taiwan, R.O.C., 1998.

3. The data is adopted from the Indicators of Education Statistics of R.O.C., 1999.

proportion of educational expenditure owns people with a low level of human capital stock, the price of children is cheap. This will lead to a substantial population growth. As the country develops and the proportion of educational expenditure continues increasing, the price of children becomes more expensive. The growth of population then slows down.

This model may also exhibit multiple equilibria. In a stagnant equilibrium, high fertility exists with a low female participation rate. However, in a perpetual growth equilibrium, a low fertility rate is present with a high female labor supply. Initial conditions may determine a country's long-run equilibrium. Countries with a low initial level of human capital may lead to a stagnant stage with high population growth and low female labor supply. Countries with a high initial level of human capital may reach a persistent growth stage with low fertility and a high female participation rate. By numerical simulation, we can depict the path of economic growth. We find that an autonomous increase in the educational expenditure may move the economy from a stagnant stage to a growth one. Empirically, we collect Taiwan data to test the prediction of our model. The empirical result shows that our theory can explain the growth experience of Taiwan quite well.

The rest of this paper is organized as follows. Section II constructs a basic model and uses a simulation to demonstrate the path of different equilibria. In Section III, we examine Taiwan's data and verify whether it follows the predictions of our model. Section IV summarizes the results and offers a conclusion.

II. Basic Model

Assume that the population is N_t units at point t in time and each unit points to a pair of parents. For simplicity of analysis, we also suppose that a husband cannot affect his wife's decision on the allocation of time.[4] We thereby exclude the role of a husband from our model. In particular, the husband's income is omitted. Furthermore, following the BMT model, we assume that the family dynasty head maximizes a dynastic utility function that exhibits a purely altruistic motive for having children. The objective function is

$$V_t = \ln C_t + a n_t^{1-e} V_{t+1}, \tag{1}$$

where V_t and V_{t+1} denote the utilities of a parent and each child, respectively. Term n_t is the number of children per parent at time t and it also denotes the gross growth rate of the population. The letter "a" is the degree of pure altruism of parents toward children, while e is the constant elasticity of altruism per child.[5] The restriction on e is $0 < e < 1$. It follows that the discount rate of generation t decreases in the number of children.

The consumption is defined as the difference between total production and educational expenditure on all children.

4. The empirical data of male labor supply shows that the number of children has little effect on the male labor supply.

5. See the BMT model for a derivation on this point.

$$C_t = l_t(\overline{H} + H_t) - n_t l_t b(\overline{H} + H_t), \tag{2}$$

where the letter "b" is a constant proportion of total production. Parents spend this amount of production on education for each child. Term l_t is the working hours, H_t is the human capital per capita at time t, and $\overline{H}$ is the stock of "raw labor capital" at the beginning of time. Let N_t denote the total population at time t, i.e., $N_t = \prod_{i=0}^{t-1} n_i$, and then n_t is equal to the ratio N_{t+1}/N_t.

Each mother is endowed with one unit of labor time. The time is allocated towards work, rearing each child (households) and teaching each child. Let v_t denote the time cost of rearing each child while h_t represents the time of teaching each child. After we normalize the time of a mother to unity, the time constraint equation becomes

$$1 = l_t + n_t h_t + n_t v_t \; . \tag{3}$$

From (3), it is easy to see that if a mother works more, she only has less time to stay home to teach her children. Notice, however, that with a higher income she can send her children to a baby sitter, kindergarten or supplemental school. Alternatively, if she stays home, she can teach her children by herself. Both supplemental and home education are inputs of the human capital accumulation function. Specifically, we assume a Cobb-Douglas function of the human capital accumulation.

$$H_{t+1} = A(h_t)^{\alpha}(bl_t)^{\beta}(\overline{H}+H_t), \tag{4}$$

where the letter "A" denotes a positive technological parameter. Terms a and b are shares of the respective inputs in human capital production. We assume that $a + b = 1$. We use Equation (4) to capture the idea that formal and in-home schooling are imperfect substitutes in accumulating human capital. Both of them are essential.

The family dynasty head is assumed to solve the following maximization problem.

$$\text{Max } V_t = \ln C_t + a n_t^{1-\alpha} V_{t+1}$$

$$\text{subject to } C_t = l_t(\overline{H} + H_t) - b n_t l_t(\overline{H} + H_t),$$

$$1 = l_t + n_t h_t + n_t v_t \; ,$$

$$H_{t+1} = A(h_t)^{\alpha}(bl_t)^{\beta}(\overline{H}+H_t).$$

By consecutively using the objective utility function, we can construct the following Lagrangian function.

$$L = \sum_{t=0}^{\infty}\{a^t N_t^{1\text{-}\hat{a}} \ln C_t - \ddot{e}_t[C_t - l_t(\overline{H}+H_t) + bn_t l_t(\overline{H}+H_t)]\}, \tag{5}$$

where l_t is the Lagrange multiplier. Applying Equations (3) and (4) to the Lagrangian function (5), we have

$$L = \sum_{t=0}^{\infty}\{a^t N_t^{1\text{-}\hat{a}} \ln C_t - \ddot{e}_t[C_t - l_t(\overline{H}+H_t) + bn_t l_t \frac{H_{t+1}}{A(\frac{1-l_t}{n_t} - v)^{\acute{a}}(bl_t)^{\hat{a}}}]\}. \tag{6}$$

First of all, differentiating Equation (6) with respect to the consumption for time t, we obtain the following first-order condition.

$$\ddot{e}_t = a^t N_t^{1\text{-}\hat{a}}/C_t. \tag{7}$$

The left-hand side denotes the shadow price of per capita consumption at time t. The right-hand side of Equation (7) denotes the marginal utility of consumption at time t. Using Equation (7), we can further derive Equation (8) below.

$$\ddot{e}_{t+1}/\ddot{e}_t = a^t n_t^{1\text{-}\hat{a}} C_t/C_{t+1}. \tag{8}$$

The left-hand side of Equation (8) is the ratio of the shadow prices of consumption at time t and $t+1$. Equation (8) equates it to the marginal rate of substitution between the consumption at time t and $t+1$.

Secondly, the first-order condition with respect to the human capital at time $t+1$ is

$$\ddot{e}_{t+1}\, l_{t+1} = (\ddot{e}_t b n_t l_t)/A(\tfrac{1-l_t}{n_t} - v_t)^{\acute{a}}(bl_t)^{\hat{a}}. \tag{9}$$

The left-hand side of Equation (9) represents the marginal value of an additional investment on human capital. This measure equals the product of the marginal productivity of human capital and the shadow price of consumption. Notice that given the number of children and working hours, an increase in the human capital investment at time $t+1$ is possible only with an increase in the level of itself at time t. One can see that the right-hand side measures exactly the marginal cost of investment on children's human capital at time $t+1$. Parents will invest in children's human capital until its marginal benefit is equal to its marginal cost.

From Equations (8) and (9), we have

$$C_{t+1}/an_t^{1\text{-}\hat{a}}C_t = l_{t+1}\, A(\tfrac{1-l_t}{n_t} - v_t)^{\acute{a}}(bl_t)^{\hat{a}}/(bn_t l_t). \tag{10}$$

Equation (10) shows that the marginal rate of substitution between per capita consumption at time t and $t+1$ is equal to the rate of return in human capital. This rate of return depends on l_t, l_{t+1} and n_t.

Thirdly, we derive the first-order condition with respect to the population N_t.

$$\begin{aligned}(1-\varepsilon)a^t N_t^{-\varepsilon}\ln C_t = {} & \lambda_t \frac{\partial n_t}{\partial N_t} l_t b(H_t+\overline{H}) + \lambda_{t-1}\frac{\partial n_{t-1}}{\partial N_t} l_{t-1} b H_{t-1} \\ & + \lambda_t n_t l_t b \frac{\partial H_t}{\partial N_t} + \lambda_{t-1} n_{t-1} l_{t-1} b \frac{\partial H_{t-1}}{\partial N_t}.\end{aligned} \tag{11}$$

The left-hand side of Equation (11) denotes the marginal utility from an increase in the total number of children at time t. The right-hand side denotes its cost. Because the total number of children at time t is born to those born at time $t-1$, an increase in the total number of children at time t requires a corresponding change in the total number of children at time $t-1$. Furthermore, at every moment in time, an increase in the total number of children incurs two types of cost. The first is the direct cost for raising all children. The first and second terms of the right-hand side of Equation (11) denote exactly this cost. The second type of cost is an indirect cost. When the number of children increases, it crowds out the teaching time per child at home. Therefore, it reduces the pace of accumulating human capital. These effects on cost are measured by the third and the fourth terms of (11).

The first-order condition with respect to working time l_t is finally

$$\begin{aligned}\lambda_t\Big[(\overline{H}+H_t) - bn_t \frac{H_{t+1}}{A(\frac{1-l_t}{n_t}-v)^{\alpha}(bl_t)^{\beta}}\Big] = {} & \lambda_t\Big[\alpha b l_t \frac{H_{t+1}}{A(\frac{1-l_t}{n_t}-v)^{\alpha+1}(bl_t)^{\beta}} \\ & - \beta b n_t \frac{H_{t+1}}{A(\frac{1-l_t}{n_t}-v)^{\alpha}(bl_t)^{\beta}}\Big].\end{aligned} \tag{12}$$

The left-hand side of Equation (12) shows the net value of the marginal product of l_t, while the right-hand side of Equation (12) stands for the marginal cost of l_t. There are two forces acting behind the latter. First, when a mother goes to work, she has less time to teach her children at home. This force acts adversely on human capital accumulation. However, the mother thereby can pay for the expense of formal or informal schools. This improves the human capital accumulation, as what the right-hand side of Equation (12) tells us.

Using Equation (4), we can simplify Equation (12) into

$$\overline{H} + H_t = bn_t(\overline{H}+H_t) + \alpha b l_t \frac{(\overline{H}+H_t)}{\frac{1-l_t}{n_t}-v} - \beta b n_t(\overline{H}+H_t). \tag{13}$$

After further arrangement of Equation (13), we have

$$l_t = (\boldsymbol{a}bv_t)n_t^2 - (\boldsymbol{a}b + v_t)n_t + 1. \tag{13'}$$

Equation (13′) shows us the relationship between the working hours and fertility rate along an optimal path. We graph it in Figure 3.1.

Figure 3.1 The Optimal Path between Working Hours and Fertility Rate

As shown in the figure, other things being equal, when the number of children is greater than $\tilde{n}$, an increase in the number of children will encourage the mother to spend more time working. However, when the number of children is less than $\tilde{n}$, female labor supply has a negative relationship with fertility. In view of (12), one can see the economic intuition behind this interesting relationship. First, from the left-hand side of Equation (12), when the fertility rate increases, it affects adversely the marginal benefit of working hours. Therefore, it will discourage female labor supply. Second, from the first term of the right-hand side of Equation (12), we see that an increase in the fertility rate reduces the time of in-home schooling. Therefore, it raises the marginal cost of working hours and discourages them. Thirdly, from the second term of the right-hand side in (12), the increase in fertility raises total family income, thus lowering the marginal cost of working hours. As a result, depending on how these three forces interact with each other, an increase in the fertility rate may raise or lower the working hours.

When fertility increases, a mother alternatively has to spend more of her time taking care of her children at home. Therefore, the opportunity cost of working hours increases and it discourages female labor supply. However, the increase in fertility also incurs more expenditure on children. In order to finance the expense, the mother may spend more time at work. This intuitively explains the ambiguous relationship between working hours and fertility. We summarize the findings in the following propositions.

Proposition 1: *Other things being equal, when the fertility rate is higher than* $\tilde{n}$ *, an increase in the fertility rate affects positively the female labor participation rate. On the other hand, when the fertility rate is below* $\tilde{n}$ *, it affects negatively the female labor force participation rate.*[6]

Now we can derive the steady state equilibrium from the above equations. First of all, in the growth equilibrium the raw labor capital $\overline{H}$ is relatively small. We neglect it in the mathematical operation. By combining Equations (10) and (13'), we obtain an explicit solution for the steady state variables in our model. Let a variable with an asterisk denotes its equilibrium value in the steady state. We thus have

$$n^* = (a/b)^{1/â} , \tag{14}$$

$$l^* = [1 - v(a/b)^{1/e}][1 - \alpha b(a/b)^{1/e}] , \tag{15}$$

$$1 + g^* = H_{t+1}/H_t = C_{t+1}/C_t = A(\frac{1-l_t}{n_t} - v)^a (bl_t)^b . \tag{16}$$

The letter ' g' stands for the growth rate. By substituting Equations (14) and (15) into Equation (16), we obtain

$$1+ g^* = Aá^{á} b[1- v(a/b)^{1/â}][1- \alpha b(a/b)^{1/â}]^{â}. \tag{17}$$

Proposition 2: *In the growth equilibrium, an increase in the proportion of educational expenditure (1) raises a mother' s working time, (2) reduces the fertility rate and (3) improves the growth rate.*

Proposition 2 says intuitively that when the educational expenditure rises, a mother will allocate more of her time to work. Therefore, she can invest more in the human capital of her children. As a result, the growth rate increases. Also, when the educational expenditure becomes more expensive, the cost of having children will be higher. Consequently, a mother will have less children and fertility goes down.

We furthermore obtain the proposition regarding the effect of changes in the fixed time cost of rearing children and the degree of altruism toward children.

Proposition 3: *(1) An increase in the fixed time cost of children,* v *, has no effect on fertility. It leads to a decrease in the participation rate and the growth rate. (2) A higher degree of altruism leads to a decrease in the participation rate and growth rate, but it raises the fertility rate.*

6. We recognize that the fertility rate is an endogenous variable in our model. However, we believe that it is important to report the way that female labor participation is affected by fertility in our model.

Propositions 2 and 3 have interesting implications for a growing economy or for countries with different environmental states. For example, if several countries have different policies on educational expenditure, our model predicts that the growth rate and female participation rate will be higher in those countries with higher educational expenditure than in the others. However, the fertility rates of the former will be lower than the latter. If, due to the lower fixed time cost of children, some countries have higher growth rates than others, our model implies that all these countries may have the same fertility rate. Similar reasoning may be applied to the cases with different degrees of altruism toward children over time in a given country.

In our model there next exists a stagnant equilibrium. It occurs when the condition $H_t = H_{t+1} = H$ holds. In the stagnant equilibrium, since $H_{t+1} = H_t$, Equation (10) becomes

$$a n_t^{-\beta} A(\tfrac{1-l_t}{n_t} - v)^{\alpha} (b l_t)^{\beta} / b = 1. \tag{18}$$

Combining Equations (13) and (18), we can derive the number of children, n_s, in the stagnant equilibrium.

$$A a \alpha^{\alpha} (1 - nv)(1 - \alpha bn)^{\beta} = n^{\beta}. \tag{19}$$

From Equation (19), one can verify that the fertility rate in the growth equilibrium n^* is less than that in the stagnant equilibrium n_s. One can also verify that n_s is greater than $\tilde{n}$. Therefore, we obtain the following proposition.

Proposition 4: *The fertility rate is lower in the growth equilibrium than that in the stagnant equilibrium.*

When the economy is in the stagnant stage, the relatively low rate of return of human capital results in a low investment in human capital. A lower level of human capital denotes a lower shadow price of children. Consequently, parents would prefer more children to investment in children' s human capital, and thus the fertility rate is high.

A further proposition considers the underdeveloped equilibrium:

Proposition 5: *There is no underdeveloped equilibrium with $H_t = H_{t+1} = 0$ in our model.*

Proof: If $H_t = H_{t+1} = 0$, by Equation (4) we can obtain $h_t = \dfrac{1-l_t}{n_t} - v = 0$. From Equation (13), we have $n = 0$ and $l = 1$. This means that an inequality must hold for Equation (11), i.e., the left-hand side of Equation (11) must be less than the right-hand side. However, when the fertility rate n equals zero, the right-hand side is equal to zero. Consequently, the left-hand side of Equation (11) is less than zero. This result conflicts with the assumption that consumption must be positive. It proves that the model does not have an equilibrium with $H_t = H_{t+1} = 0$.

In the last part of this section, we use finally a numerical example to demonstrate the path of demographic transition. We start with a set of parameter values which drive our model into a stagnant equilibrium. We then increase the value of educational expenditure to examine its impact on our model. We also show the dynamic transition in our model. Let us consider a case with the following values for the parameters in our model: $A = 13$, $a = 0.2$, $\boldsymbol{e} = 0.35$, $\boldsymbol{a} = 0.6$, $b = 0.14$, $v = 0.08$ and $\overline{H} = 0.1$.

In this case the economy will grow into a stagnant equilibrium with $n_s = 2.539$, $l_s = 0.615$, and $H_s = 3.217$. By using the stagnant equilibrium as an initial point, we find that if the proportion of educational expenditure b rises from 0.14 to 0.15, the model will grow into a perpetual growth path as Figures 3.2, 3.3 and 3.5 show.

Figure 3.2 The Path of the Fertility Rate

Figure 3.2 demonstrates that an increase in b has a negative effect on fertility. It drives the fertility rate monotonically down to the growth equilibrium of 2.275. Figure 3.2 also shows that the path of fertility follows the demographic transition. The high fertility rate exists in the stagnant equilibrium in which human capital is low, and an increase in b leads to an increase in the cost of education. A mother would like to improve the quality of children instead of the quantity of children. This leads to a gradual reduction in fertility until it reaches the steady state value.

In Figure 3.3, an increase in the educational expenditure leads to a gradual increase in the working hours l_t. It climbs from the stagnant equilibrium value to the growth equilibrium with $l_t = 0.651$. The working time path symbolizes the path of the married women participation rate in Taiwan.[7]

7. Killingsworth and Heckman (1986) showed this upward trend in the married women' s participation rate in

Figure 3.3 The Path of a Mother's Working Time

Figure 3.4 The Trend of Married Women's Participation Rate in Taiwan (1964-1996)

different countries.

Figure 3.4 shows the trend in Taiwan' s married women' s participation rate from 1964 to 1996. From 1976 onwards, there is an increasing trend in the rate, with the increasing trend explicitly upward from 1981 to 1987. However after 1987, the trend slows down. Referring to Figure 3.3, one can see that it may illustrate the take-off of married women participation, which moves from the stagnant equilibrium to the growth equilibrium. The trend pattern in our simulated case looks just like the trend pattern since 1981 in Taiwan.

Figure 3.5 The Path of Human Capital

In Figure 3.5, the proportion of educational expenditure b is set finally by 0.14. Line I is the path of human capital accumulation. It reaches a stagnant equilibrium where the value of human capital is 3.217. If the value of b rises to 0.15, its path will gradually reach a perpetual growth path from point W to point A, as line II shows. As a result, we may claim that an autonomous increase in educational expenditure may move the economy from an underdeveloped economy to a developed one.

III. Empirical Study

This section tests the propositions of our model and uses the economic growth experience of Taiwan as our data set. According to our model, an increase in the proportion of educational expenditure leads to an increase in a mother' s working time, a decrease in the fertility and an increase in the growth rate.

Married women' s working hours l are not the same as the married women' s participation rate. For an empirical test, working hours should be defined as $l = (h_w/h_L)(E_F/N_F) = (h_w/h_L)P_F$. Term h_w denotes married women' s working hours and

h_L denotes the total hours that married women have. Term E_F is the number of people in the married women's labor force, N_F is the number of the population over 15 years old, and P_F is the married women's participation rate. Because most people allocate one-third of their time for work, we approximate the ratio of working hours to total hours as one-third, i.e., $h_W / h_L \approx 1/3$. Consequently, the normalized married women's working hours l are approximately $\frac{P_F}{3}$.

We can find P_F from the *Yearbook of Manpower Survey Statistics, R.O.C.* The letter "g" denotes the growth rate of per capita real GNP collected from the *National Income, R.O.C.* The letter "n" denotes the married women's total fertility rate collected from the *Demographic Statistics R.O.C*. Here, the letter "b" is the proportion of educational expense in household expenditure collected from the *Report on Family Income and Expenditure Survey*. The letter "I" is the real disposable income per household. The data is available in the *Report on Family Income and Expenditure Survey*. We use it as a proxy of family income. The letter "E" is the average number of years of education that female employees accept. We find the data on education in the *Yearbook of Manpower Survey Statistics, Taiwan Area, R.O.C*. In addition to the predetermined variables E, I, and b, we also take per capita GNP, i.e., Y, into account. It has some influence on the growth rate g.[8] In our model l, g and n are the explained variables.

We construct an econometric model with a system of structural equations. These equations mirror the first-order conditions in our theoretical model.

$$g_t = \alpha_0 + \alpha_1 l_t + \alpha_2 n_t + \alpha_3 Y_t + \varepsilon_1, \tag{20}$$

$$l_t = \beta_0 + \beta_1 n_t + \beta_2 b_t + \beta_3 E_t + \varepsilon_2, \tag{21}$$

$$n_t = \delta_0 + \delta_1 b_t + \delta_2 E_t + \delta_3 I_t + \varepsilon_3. \tag{22}$$

The above variables denote their natural-log values, while this research uses the yearly data from 1972 to 1998. The three-stage-least-square method is applied to run the simultaneous equations. Theoretically, our model predicts that the signs of α_1 and β_2 are positive, while α_2, α_3 and β_1 must be negative. The remaining coefficients are indeterminate. The results of our empirical test are reported in Table 3.1.

The regression result of Equation (20) is reported in the second row of Table 3.1. It shows that the married women's participation rate is positively related to the growth rate as expected. Furthermore, the fertility rate is negatively related to the growth rate. The level of per capita GNP indeed does negatively affect the growth rate.

8. See EL (1991) for a reference.

Table 3.1 The Regression of Simultaneous Equations from First-order Conditions

	Intercept	l	n	Y	b	E	I
g	32.764 (1.035)	0.856 (0.258)	−2.397 (−0.975)	−1.228 (−0.976)			
l	8.505* (5.828)		−0.734* (−5.056)		0.395* (4.056)	−0.440* (−2.748)	
n	7.973 (3.470)				−0.413 (−1.498)	−1.340* (−3.011)	0.245 (0.898)
R^2	0.8715						

* denotes the 5% level of significance.

The third row in Table 3.1 reports the regression result for Equation (21). It illustrates that the married women's participation rate is negatively related to the fertility rate. The coefficient is statistically significant. Consequently, it confirms the prediction of the growth equilibrium in Proposition 1. That is, when the fertility rate is below $\tilde{n}$, it negatively affects the female labor force participation rate. The proportion of educational expenditure has a positive effect on the married women's participation rate, and it is statistically significant. In Taiwan educational expenditure indeed is an important factor affecting the female participation rate. However, the level of female education significantly and negatively affects the participation rate. This result implies that women with higher education will prefer staying home to working.

The fourth row shows that educational expenditure is negatively related to fertility as we expected. Since an increase in educational expense raises the cost of educating children, a mother prefers the quality of children to quantity. Therefore, she will prefer a small number of children. Furthermore, the level of female education shows a negative effect on the number of children. This matches the fact that when the mother's time cost becomes more expensive, a better-educated mother will have fewer children. With regard to disposable income per household, it is positively related to fertility. The high-income family has more children than does the low-income family.

The above results meet our predictions in Proposition 2. It also shows that our model explains very well Taiwan's growth experience from the aspect of the female labor supply. An increase in the proportion of educational expenditure over time leads to an increase in the married women's participation rate and an increase in the growth rate. However, it results in a decrease in the fertility rate.[9]

Depending on the level of the fertility rate, Equation (13) predicts finally an indeterminate relationship between the fertility rate and female labor participation rate. We now use international data to investigate this relationship. We will run different regressions of the female participation rate on the fertility rate for countries with different levels of per capita GNP. We classify those countries according to low-income, middle-income, and

9. Because of the limited data sets in Taiwan, we could not test whether the time cost of rearing children, v, and the degree of altruism, a, affect the growth equilibrium as predicted in Proposition 3.

high-income, respectively. Using the World Bank classification, 49 countries are in low-income economies, 57 in middle-income economies, and 24 in high-income economies. The empirical results are reported in Table 3.2.

Table 3.2 The Regressions of Female Labor Force Participation Rate on the Fertility Rate for Different-income Economies

	Low-income	Middle-income	High-income
Intercept	40.308*	50.428*	41.117*
	(11.560)	(22.303)	(10.614)
Fertility Rate	0.437	−4.331*	−0.162
	(0.686)	(−6.195)	(−0.075)
R^2	0.0101	0.4200	0.0003

Note: The data are collected from "World Development Report" (1996).

In Table 3.2 the female labor force participation rates are positively related to the total fertility rate in the low-income countries. On the other hand, a negative relationship exists between the female participation rates and fertility rates in the middle and high-income countries. This outcome supports the hypothesis in Proposition 1 and implies that in underdeveloped economies, a higher fertility rate coincides with a higher female labor force participation. Since most developing countries engage in agriculture, women who work on the farm near their house can work as well as take care of their children. As countries become more advanced, their service industry develops and attracts more women willing to find jobs in this industry. On the other hand, in the more developed economies, high female labor force participation rates coexist with low fertility rates.

IV. Conclusion

During the process of economic growth, the interaction between fertility and female labor supply is significant. However, few studies discuss together the relationship between female labor supply, fertility and growth. Taiwan's economic development shows the fact that during 1960s and 1970s, female earnings not only subsidized part of the family's necessary expenses, but also contributed to the investment on human capital of family members. As an economy develops, a mother cannot just stay home to teach her children as before.[10] She has to join the job market, and further accumulate her own human capital and financial ability. The financial support for children's human capital becomes more important, and even surpasses mother's time of teaching at home.

Our study combines these two factors as the inputs of children's learning capacity. Through educational expenditure, we connect female labor supply, fertility and growth. We obtain that a high-income country can be characterized with high female participation, low fertility and high growth. A low-income country has the opposite characteristics. Furthermore, low-income countries may move from an undeveloped stage to a developed

10. See Lui (1983).

stage, if they raise the proportion of household educational expenditure. Governments may deduct the educational expenditure from a household's income tax to encourage parents' educational expenditure. With respect to time-series data in Taiwan and data across countries in the world, our empirical results justify the model's predictions.

There are many other factors such as social and cultural changes that affect the interrelationship between female labor supply, fertility and growth. For example, one is the social norm of accepting female worker in different position. In order to explore the real aspect of the interaction between mothers' working decision and children's quantity and quality, we will extend our model to include the role of husbands. Finally, the proportion of educational expenditure can be an endogenous variable affected by income. To further endogenize b would require another study to encounter its possible implications.

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