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AN ECONOMETRIC SIMULATION OF THE EFFECTS OF FERTILITY CONTROL ON THE ECONOMY OF TAIWAN.

UNIVERSITY OF HAWAII, PH.D., 1979

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AN ECONOMETRIC SIMULATION OF THE EFFECTS OF FERTILITY CONTROL ON THE ECONOMY OF TAIWAN

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE
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MAY 1979

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ABSTRACT

The purpose of this study is to examine the effects of three fertility trends--normal, low, and very low--on economic growth, and to estimate the economic value of averted births in terms of market goods. To do this, we have constructed a disaggregated economic-demographic model which treats demographic variables as endogenous. The model presents a set of theoretically valid equations. Labor force participation rates are a function of (1) wage rates and (2) current and past fertility. Per capita food consumption, not per capita income, is used as proxy for nutrition. Because many investments do not begin to contribute to production for the first few years after they appear in the capital stock owing to planning and construction lags, effective capital input instead of capital stock is used in the production function. The effects of age and sex composition are minimized by using the number of equivalent adult consumers in the consumption function and by setting up equations for age- and sex-specific fertility, survival, and labor force participation rates.

The model, involving a high degree of interrelationship among the variables, is a neoclassical open-economy growth model. Except for the depreciation equation, which was estimated by ordinary least squares, all the behavioral equations were estimated by using the two-stage principal-component method. The validity of the model was evaluated by performing historical simulation; to do so, the model was solved by the Gauss-Seidel method because the model is non-recursive and includes nonlinear variables. The results are all reasonable: (1) the root-mean-square percentage errors are all low regardless of the initial period of the simulation,

and (2) the RMS forecast errors are all as small as those of historical simulation. In estimating the gains from fertility reduction obtainable by the participating families the following relations were taken into account: (1) the increase in output that would otherwise have been produced by the averted children, (2) the increased output derived from increased female labor force participation, (3) the consumption averted by the fertility reduction, and (4) the difference in consumption patterns by age and sex.

The demographic findings show that, because of the young age structure, even if fertility were to reach replacement level immediately, the population in Taiwan would still increase by more than 94% before it stabilized.

The economic findings indicate that the low and very low fertility trend assumptions eventually produce slightly smaller GDP and smaller GDP per capita than the normal fertility trend assumption. However, the low and very low fertility assumptions generate substantially larger GDP and larger GDP per capita in the near future up to 40 to 60 years. Consequently, the economic value per averted birth obtainable by the participating families is still positive--nearly $20,443 (1971 N.T. dollars).

This study yields important policy implications. Because lower fertility has immediate economic advantages, it may be beneficial for a developing country with a high birth rate to reduce fertility in order to break out of the low-income "trap" as soon as possible. The normal and the lower fertility trend populations all generate very high GDP per capita in the long run. It therefore may not be of primary importance that the lower fertility trend populations eventually produce slightly smaller GDP per capita than does the normal fertility trend population; it may be of much greater importance, from the economic point of view, for a developing country to break out of poverty.

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CHAPTER 1

INTRODUCTION

I. OBJECTIVE AND FEATURES OF THE STUDY

It is not sufficient to claim that the economic benefit from population control is substantial; we need to show it to be so quantitatively. The purpose of this study is to formulate an economic-demographic model that can be used for simulating the effects of different fertility trends on economic growth in Taiwan and thus in evaluating the economic gains of averted births and their distribution between the participating families and the country at large.

There are several reasons for selecting Taiwan as a case study. First, both population growth and economic development are subjects of major concern in Taiwan. Taiwan is one of the most densely populated countries, with, in the past 25 years, one of the fastest growing populations and economies. At the same time, the rate of fertility reduction in Taiwan has also been among the most rapid. The average annual growth rate of gross national product (GNP) during this period has been about 8%; in contrast to this, the average annual growth rate of GNP per capita has been only about 5%. The government has attempted to increase the GNP growth rate while attempting to reduce the fertility rate through the family planning program.

Second, the family planning program in Taiwan has played an important role in economic development since the late 1960's despite strong political opposition. There have been arguments concerning the advantages and disadvantages of fast population growth and whether, if slower population growth is preferable, the family planning program is effective in reducing fertility.

Third, Taiwan's demographic and economic data are readily available and more reliable than those of most other developing countries.

This study includes a number of unique features which considerably improve on the existing literature. Among those features are:

(1) The simulation of the effects of different fertility trends on economic growth with a disaggregated economic-demographic model incorporating demographic variables as endogenous.

(2) Since the model is non-recursive and nonlinear, we solve it by the Gauss-Seidel method [31] to avoid errors resulting from linearization.

(3) We perform a historical simulation to test and evaluate the performance of the model [73].

(4) We use the number of equivalent adult consumers and the age- and sex-specific fertility, survival, and labor force participation rates to account for the effects of changing age and sex composition.

(5) Labor force participation rate in our model is a function of current fertility rate and past fertility rates.

(6) We take into account the fact that a substantial part of current investment does not increase output for the first few years because of the time involved in planning and construction.

(7) In evaluating the gain per birth averted captured by a participating family, we consider the possibility that the averted child after maturity might either have left the parents or have stayed with the parents.

II. RECENT ECONOMIC AND DEMOGRAPHIC TRENDS IN TAIWAN

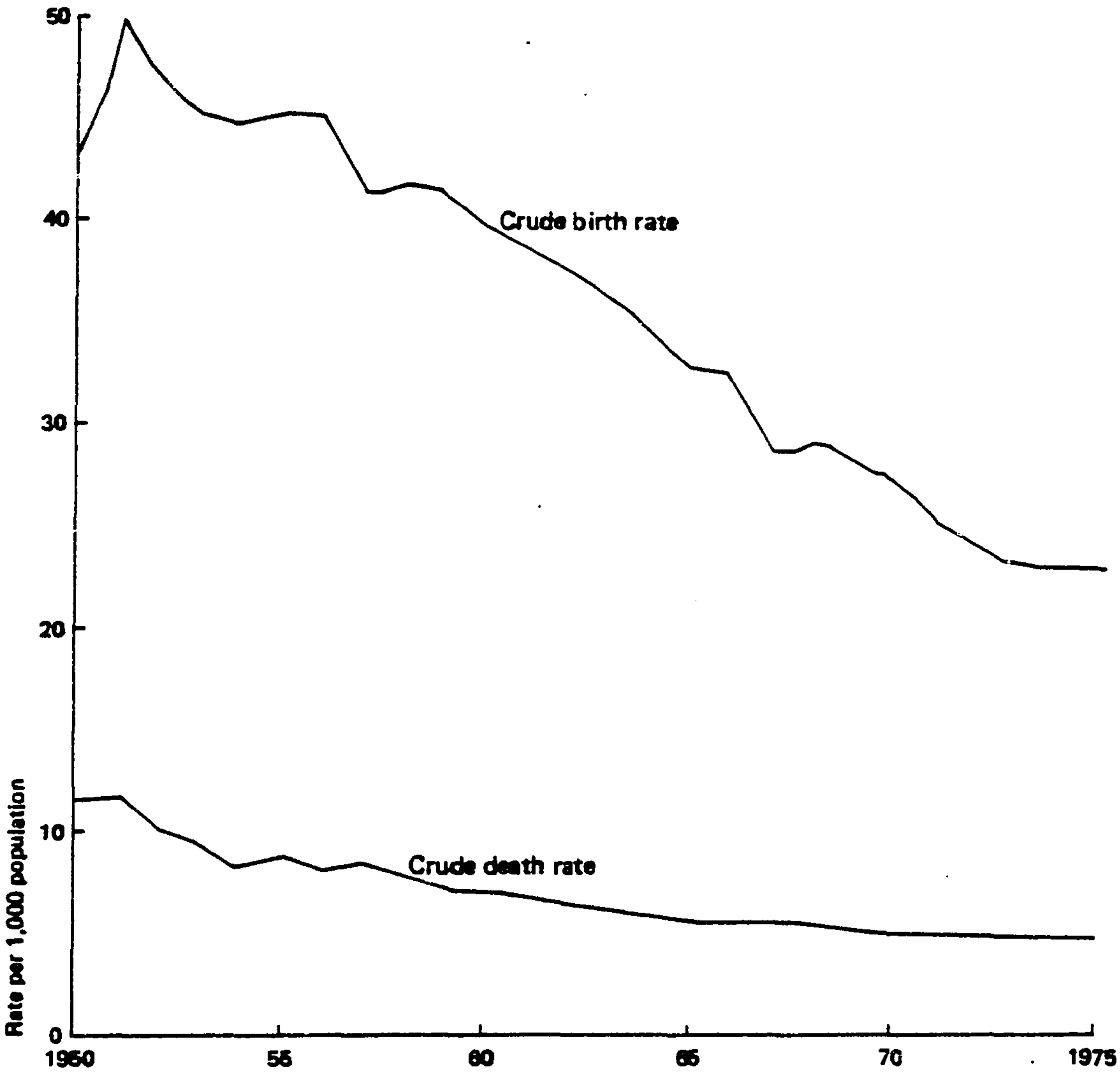
Taiwan is located on the busiest air and sea routes of Southeast Asia. The island, shaped like a tobacco leaf, is nearly 36,000 square kilometers in area. Only about a quarter of the land is good for farming. It is not rich in mineral deposits. The population now is over 16 million; the population density is among the highest in the world--around 450 per square kilometer, or about 1,800 per square kilometer of cultivated land [84]. The population in Taiwan has doubled in less than 30 years. In 1975, the natural rate of growth was 1.83%; if this growth rate were maintained the population would double in 38 years. Although in the last 30 years per capita income has tripled, the absolute value is still low--only US$700 in 1975.

A. Demographic Trends

Over the period 1953-1975, international migration was so small as to have a negligible effect on population growth in Taiwan. The mortality rate in Taiwan over the same period fell to such a low level that significant further mortality decline seems unlikely. The rate fell from 9.4% in 1953 to 5.0% in 1969, and has thereafter remained fairly constant at a level of around 4.8%, as shown in Figure 1.1. Therefore, over this period, the most important determinant of population growth was the fertility rate.

During the period 1953-1975, the female mortality rate fell faster than the rate for males, declining from 9.34% in 1953 to 3.95% in 1975 while the male mortality rate fell from 9.51% in 1953 to 5.36% in 1975. The degree of mortality reduction varied across age groups; the greatest declines coming in the age group 1-4 years old. With 1953 age-specific mortality rates as a base for comparison, female and male mortality rates

FIGURE 1.1 VITAL RATES IN TAIWAN, 1953–75



Sources: Republic of China, Ministry of the Interior, *Taiwan-Fukien Do Demographic Fact Book* (Taipei, Taiwan, 1961–77).

in the 1-4 years age group fell by 91.3% and 87.8%, respectively. The degree of the reduction was proportionately smaller in each higher age group, with the smallest reduction being among the oldest age groups. The crude death rate will probably rise as the age-structure of the population shifts to older ages.

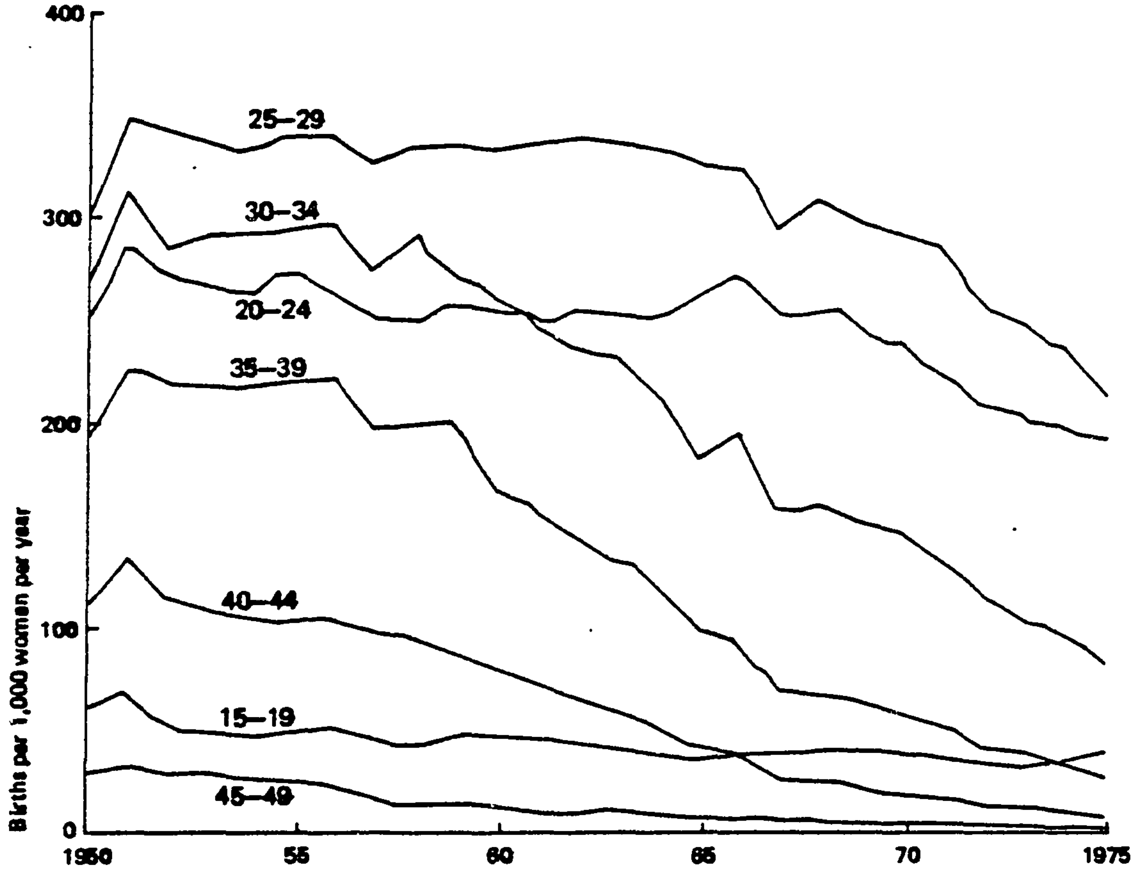
Figure 1.2 shows the trends of age-specific fertility rates. The decline in the rates was not uniform among age groups; the rate of decline was faster for the later years of childbearing (aged 30-49), but slower for the earlier years of childbearing (aged 15-29). During the 1950's, the annual natural increase rate was extremely high--over 30%--so in the 1970's there has been a rapid increase in the female population in the childbearing ages. Consequently, although the gross reproduction rate in 1975 was only 1,383--not much greater than the replacement level--the crude birth rate was still as high as 23%.

The gross reproduction rate is a measure of the number of daughters born to a hypothetical cohort of 1,000 women, assuming a fixed schedule of age-specific fertility rates and no deaths before the end of the childbearing period. The net reproduction rate is a similar measure except that it takes into account female mortality. We assume that fertility reaches replacement level when the gross reproduction rate declines to about 1,050, because countries with a net reproduction rate of about 1,000 have been found to have a gross reproduction rate of about 1,050 [110].

B. Economic Trends

In the past 25 years the double goals of rapid economic growth and low unemployment rate have generally been achieved. The gross national product has increased substantially. In 1976, the GNP was

FIGURE 1.2 AGE–SPECIFIC FERTILITY RATES IN TAIWAN, 1953–75



Source: Republic of China, Ministry of the Interior, *Taiwan-Fukien Demographic Fact Book* (Taipei, Taiwan, 1961–77).

NT$651.5 billion (US$17.1 billion), compared with only NT$17.2 billion (US$0.5 billion) in 1952. The average annual growth rate of the real GNP was more than 8%. The GNP per capita increased more than 17 times from US$45 in 1952 to US$809 in 1976. The average annual growth rate of the real GNP per capita was about 5%. The unemployment rates have remained very low, only 2.41% in 1976.

III. A BRIEF REVIEW OF THE LITERATURE

The economic-demographic models built to measure the effects of changed fertility on per capita income generally fall into three categories: (1) those which use the Harrod-Domar model and consider demographic variables exogenous; (2) those which use a neoclassical model and consider demographic variables exogenous; and (3) those which use a neoclassical model and consider demographic and economic variables interactive.

Coale and Hoover [13] pioneered the application of a macroeconomic growth model to measure the economic significance of population control in India and to test the sensitivity of their model to various assumptions concerning nondemographic variables. They used the Harrod-Domar model that assumes a constant capital-output ratio. Because the amount of labor required to produce a unit of output is given, the actual rate of growth (G_a) cannot permanently exceed the natural rate of growth (G_n). But, if $G_a < G_n$, there will be increasing unemployment [44]. If capital is fully employed, the marginal productivity of additional labor is implicitly assumed to be zero. Given that Coale and Hoover look at the short-run effects, the Harrod-Domar model is satisfactory.

The assumption of a constant capital-output ratio is reasonable for the study of the business cycle. However, when the purpose is to simulate the effect of changes in demographic variables over a century, the assumption of a constant capital-output ratio is questionable, especially when there is continuing large-scale unemployment. Jones [50], and Robinson and Horlacher [91] argue that it is inappropriate to assume a constant capital-output ratio in a model designed for the long-run analysis of economic growth.

A considerable number of economic-demographic models using the neoclassical approach have been developed in recent years. Some of these models, such as those by Newman and Allen [68], Enke et al. [26], Walsh [115], and Sigit [93], do not provide feedback from economic variables to demographic variables. Demographic variables should be included as endogenous because they are interrelated with socioeconomic variables. A number of economists who have developed models with endogenous demographic variables include Simon [95], Robinson [90], Liu [57], Encarnacion [25], Wery et al. [118], Suits et al. [99], and Suits and Mason [101] [102].

Taking into account economies of scale, the positive effects of population growth on investment, and the effects of consumption aspirations on work effort, Simon concludes that "population growth may be good for LDCs in the long run"; this conclusion is completely different from that of most economic-demographic models. To simulate the effects of various fertility rates on economic growth, he does not apply his model to any real economy; instead, he assigns parameters. His model may be inconsistent with the experience of real economies.

Liu's economic-demographic model applied to Taiwan is highly disaggregated and allows for feedback from economic to demographic variables. He argues that "a conventional exercise of assuming alternative population trends to trace the effects of population on economic development is not suggested because we found that population trends are an inseparable part of the whole sociocultural and economic growth process; any arbitrary assumption of trends in population growth is questionable" [57, p. 199]. He also finds that it is difficult to solve the model because of nonlinear variables contained in the model [57, p. 198]. This study tries to solve these two problems.

Encarnacion succeeds in projecting with a large-scale economic-demographic model, which incorporates demographic variables as endogenous, for a specific country. The model introduces a detailed demographic submodel including marriage, and considers that the positive or negative effects of income on fertility depend on the income levels. He only projects with the model, but does not use the model to simulate the effects of various fertility assumptions on economic growth.

However, Encarnacion's production function is of the linear form: $Y = a + bL + cK$. This functional form is inconsistent with economic theory for the following four reasons. First, in the linear production function, the marginal product of labor (L) is $\frac{\partial Y}{\partial L} = b$, which is independent of the level of capital (K) and of labor (L); the marginal product of capital is $\frac{\partial Y}{\partial K} = c$, which is independent of the level of labor and of capital. However, the marginal products of labor and of capital are usually assumed to depend on the capital-labor ratio.

Second, in the linear production function, if both labor and capital are zero, the product equals the constant term, which may be negative, zero, or positive. Actually, the product should be zero when labor and capital are zero.

Third, in order to maximize output subject to a given cost and to given input prices, a producer must hire the inputs in quantities until the marginal rate of technical substitution of capital for labor ($\frac{b}{c} = q$) equals the ratio of the price of labor to the price of capital ($\frac{P_L}{P_K} = q'$). In the linear production function, if q happens to equal q', the producer can use any combination of capital and labor in order to maximize output; if q does not equal q', the producer must use either all capital or all labor in order to maximize output. It is unlikely that the ratio of factor prices is exactly equal to the rate of substitution and thus a linear production function would require the producer to use only capital or only labor. However, we do observe that producers always use a combination of capital and labor.

Fourth, if capital and labor double, the product will be $Y' = a + 2bL + 2cK = 2Y - a$; therefore, the presence of increasing, constant, or decreasing returns to scale depends on whether the constant term is smaller than, equal to, or greater than zero.

BACHUE-2 by Wery, Rodgers, and Hopkins is a highly disaggregated model, including a high level of interaction between economic and demographic variables. It is a policy model designed to study the population and employment relationships. The model explicitly introduces a quite detailed labor market submodel, and the determination of income distribution, final demand, marriage, education, and migration. The demographic submodel is basically micro-oriented, although necessarily including some macro-level elements. The authors have simulated the BACHE-Philippines model, but have not published the results. Although Wery, Rodgers, and Hopkins argue that the Enke-TEMPO models [26] neglect the relevance of economies of scale, they still construct a production function which assumes constant returns to scale.

The models employed by Suits and Mason represent an extension and improvement of an earlier version compiled by Suits and others. Suits and Mason's models do have the virtue of developing and applying spline functions to capture curvilinear relationships. Suits and Mason simulate the models to evaluate the economic gains of birth control programs; they also pioneer a successful analyses of the distribution of the gains. As the authors admit, their model "speaks only of aggregates," and does not treat the cyclical age-structure effects generated by a family planning program, and accompanying economic effects.

IV. EVALUATION OF DATA

A. Demographic Statistics

The demographic statistics used for this study come mainly from two Taiwanese government sources: household registration data [86], and the population census [78] [79] [77].

Although these data are more complete and reliable than those of most other developing countries, further evaluation and a number of adjustments are needed in order to use the data in the model. It is hard to evaluate demographic data and national income statistics prior to 1953 because of insufficient information; therefore, the data prior to 1953 will not be used in the model.

1. Household Registration

The main sources of errors in the household registration data are as follows:

(1) There are late reports of births. Only about 70% of the births are reported within 15 days after the children are born; about 27% are

reported between 16 days and 6 months; and about 3% are reported after 6 months [9].

(2) There are underestimates of infant mortality mostly because of the under-registration of the infants who are born and have died in the same year.

(3) Armed forces are excluded from the registration system before 1969 for administrative reasons. As a result, there is an underestimation of the population before 1969 [120].

(4) Because many documents were left on the mainland, it was difficult to verify the exact ages of some of the people who came with the Central Government to Taiwan from the mainland in the late 1940's. This affected the reliability of the distribution. However, according to a 1970 sample census which counted military personnel, those who arrived from the mainland in the late 1940's and their offspring accounted for only 16.7% of the total population in Taiwan; and the ages of the mainlanders were distributed throughout several groups. Therefore, the accuracy of the age distribution of the total population could not have been seriously affected.

(5) The data on educational levels, economic activities, and internal migration derived from household registration are not reliable for the following reasons:

(a) It is not compulsory for people to update their registration data.

(b) There is much "red tape" involved in updating their data.[1]

(c) There is late reporting of changes in educational attainment, occupation and internal movements [83].

(d) There are incentives for not reporting changes in status.[2]

Therefore, the data on education and economic activities for this study will be obtained from the Labor Force Survey. We obtain other demographic data from Household Registration. The under-registration of births and the under-enumeration of population during the period of 1951-1973 have been adjusted by the Economic Planning Council and the Ministry of the Interior [9]. We have adjusted the 1974 and 1975 data by the same method.

2. Population Census

The four more recent population censuses were taken in 1956, 1966, 1970, and 1975. The censuses of 1970 and 1975 are sample censuses with a sampling ratio of 5%. Household registration data will be used for this study because they are more reliable than census data for the following reasons:

(1) These censuses were all conducted by temporarily organized agencies which disbanded at the completion of the census report. Clearly, personnel who are engaged temporarily cannot be expected to acquire and accumulate experience from their work [120].

(2) The 1970 and 1975 censuses are 5% sample surveys and are subject to considerable sampling variation.

B. Manpower Statistics

1. Labor Statistics

Between 1954 and 1973, labor statistics in Taiwan were compiled by different institutions, and often had different definitions and coverages. For some industries, data were not available; for other industries, surveys were duplicated and the published data by different institutions are often contradictory. Since 1973 when the DGBAS took charge of the labor statistics, there have been a number of improvements in definitions, coverages, sampling methods, survey conducting, data compiling and analysis, research, and so forth. Even so, there is still room for improvement. For one thing, it would be useful to classify the data on wage and working hours by sex and educational levels.

2. Labor Force Survey

Although the data on education and economic activities from this survey are more reliable than from household registration, they still need improvement:

(1) The Taiwan Provincial Labor Force Survey and Research Institute, a third-level organization of the Taiwan Provincial Government, is under the supervision of the Eighth Section of the Department of Social Affairs. Generally, the civil service employees in local governments are poorly paid. Because of this, the local governments find it difficult to hire skilled workers. Also, the Taipei City Government is not under the supervision of the Taiwan Provincial Government; both are separate entities under the Central Government. These separate jurisdictions created administrative problems; for example, the difficulty in solving the problem if a respondent refused to answer the questionnaire.

(2) All the sample households are selected by a stratified two-stage sampling method. The primary sampling units are hsiang, townships, districts, or cities under the jurisdiction of local governments. The ultimate sampling units are the households, selected by interviewers from household registration files by a systematic sampling method.[3] The interviewers have to interview all persons 15 years of age and over in the household samples, but they are paid by the number of households, instead of by the

number of persons, they interview. When an interviewer selects a household consisting of many persons 15 years of age and older, he might bypass it in favor of a smaller family which will take less time to interview. Thus, it is possible that this survey underestimates the civilian population of ages 15 and over, compared with household registration data.

(3) According to the interviewer's manual, the questionnaires are to be answered by the respondents themselves, except under special conditions in which the questionnaires can be answered by other family members. As a matter of fact, during the daytime interviews, most of the respondents are at work away from home. Many of the questionnaires, therefore, probably are answered by other family members who might not have been competent to answer.

(4) Although field operations are controlled by means of Program Evaluation and Review Techniques, job descriptions were not sufficiently defined for true efficiency [120].

(5) A sample size of 0.6% of the population of Taiwan is too small to produce data precise enough. The 95% confidence interval for the total labor force in October 1975 is 5.2 to 6.2 million. Such a wide interval is hardly informative.

(6) This survey does not include military personnel.

(7) The questions and format of the questionnaires are not suitable. Also, according to the interviewer's manual, the questionnaires could be answered by other family members, but the pronoun "you" is used by mistake as the subject in all questions in the questionnaires.

The Directorate-General of Budget, Accounting and Statistics (DGBAS) in the Republic of China took over the survey in July 1977. Therefore, we expect that the data will be improved in the future.

Time series data of labor force participation rate and labor force will be obtained from this survey, with adjustments according to data from the census. The weaknesses of the survey and census will directly bias the estimate of demographic variables, such as labor force participation rate, labor force, and the size and age-sex structure of the population; the weaknesses will indirectly bias the estimate of economic variables. For this reason, we carefully evaluate and adjust the data needed for our model.

C. National Income Statistics

National Income Statistics have been compiled by the DGBAS since 1953. The form and concepts generally agree with the system of national accounts recommended by the United Nations [112]. Hcwever, steps have been taken to meet the domestic requirements.

For the period 1951-1960, only annual data are available. Quarterly data for 1961-1975 have been compiled since 1966. The quarterly data are less reliable than the yearly data because of difficulties in collecting.

V. PLAN OF THE STUDY

The objective will be accomplished through the following steps. In Chapter 2, we postulate an economic-demographic model for Taiwan with demographic variables as endogenous. The estimated model is presented in Chapter 3. In Chapter 4, we test the performance of the model, and then run a number of simulations with the model, altering various parameters in fertility equations to observe the effects on economic development and to estimate the economic value of averted births. In addition, we calculate how much of the economic value of averted births is directly obtained by the participating families and how much accrues to the benefit of the country at large. Because it is unreasonable to assume constant economic structure during the whole simulation period of a century, we also test the sensitivity of the model to various alternative assumptions concerning the coefficients of the variables. The last chapter summarizes the principal findings, discusses policy implications, and suggestions for further research.

NOTES

[1] For example, if one gets a degree from abroad and wants to change one's educational data, one must translate the diploma into Chinese and get it notarized. If one changes jobs, one must get the documents from both the original and the new employers in order to update one's professional data.

[2] For instance, farmers can buy or sell land more easily than members of other professions. Civil service employees face more restrictions on going abroad, and on entertaining. It is illegal for civil service employees to go to sexual entertainment establishments or to invite people other than their close relatives to their wedding ceremonies.

[3] This procedure was what they actually did, although it was not delineated in the sample design, which instead only mentioned that the households "were selected by designated field staff following certain pertinent instructions." [107]

CHAPTER 2

STRUCTURE OF THE ECONOMIC-DEMOGRAPHIC MODEL

I. GENERAL PROPERTIES OF THE MODEL

Most economic-demographic models have concentrated on the economic consequences of demographic change and assume that demographic variables are determined by exogenous factors [25]. However, it is widely recognized that demographic variables are important endogenous variables in the economic and social processes and that the assumption of exogenous demographic behavior will introduce bias in the results [118].

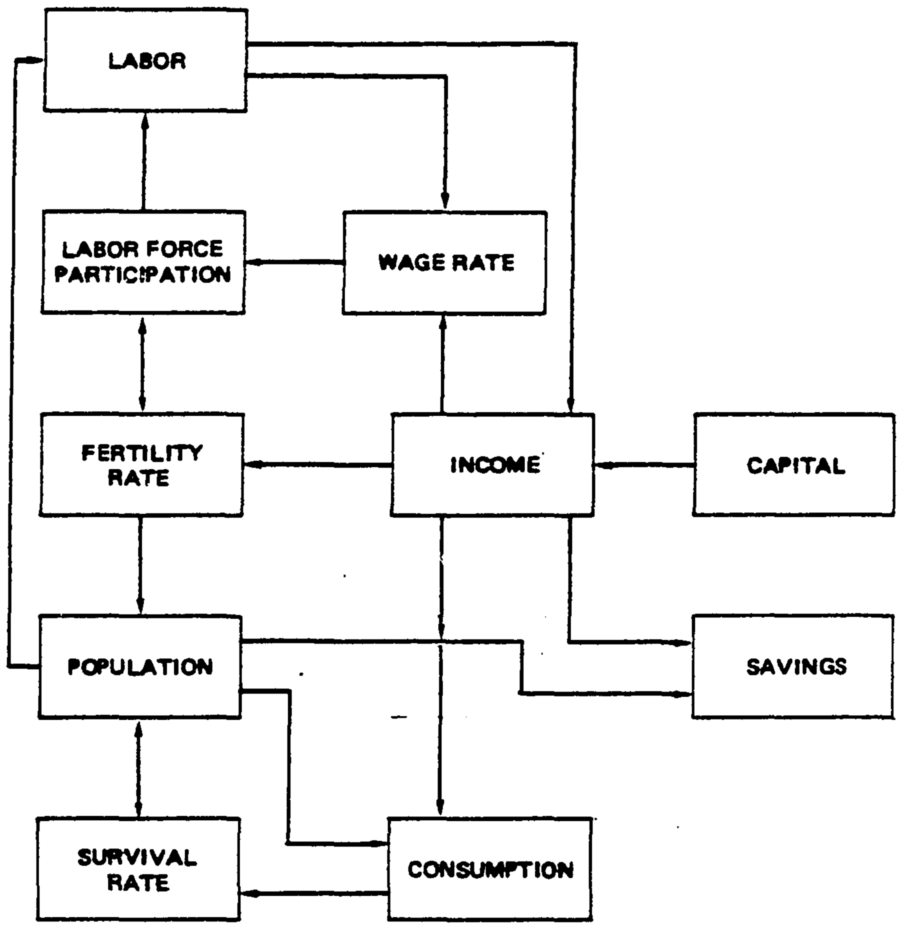
The model is a demographically oriented, neoclassical open-economy growth model. The demographic submodel includes the determinants of fertility rates, survival rates, labor force participation rates, population size, equivalent adult consumers, and labor force. Because our purpose is to simulate the effects of population change over a century, it is appropriate to apply a neoclassical growth model that assumes a continuous and well-behaved aggregate production function [91]. In our model, the Cobb-Douglas function is used.

This model is designed to simulate the effects of fertility rates on economic growth, to estimate the economic benefits of averting births, and to analyze the distribution of the benefits.

II. INTERACTIONS BETWEEN DEMOGRAPHIC AND ECONOMIC VARIABLES

The interactions between economic growth and demographic change, especially the effects of a reduction in fertility rate on the growth rate of per capita income, is easy to see from Figure 2.1, which portrays

FIGURE 2.1 INTERACTIONS BETWEEN DEMOGRAPHIC AND ECONOMIC VARIABLES (SIMPLIFIED)



the underlying structure of the economic-demographic model, and is briefly described as:

(1) The current size and age-sex structure of a population are a function of (a) the previous size and age-sex structure; (b) age-specific fertility rates, which are a function of disposable income per capita and female age-specific labor force participation rates; and (c) age- and sex-specific survival rates, which depend on food consumption per capita.

(2) Labor force participation rates are a function of (a) current and past fertility and (b) real wage rate, which is in turn affected by the size of the labor force.

(3) Labor force is determined by the age- and sex-specific labor force participation rates, and the size and age-sex structure of the population.

(4) Gross domestic product is a function of labor force and capital stock.

(5) Private consumption is a function of private disposable income, lagged private consumption, and the number of equivalent adult consumers.

(6) Government expenditures depend on the size of the population and on gross domestic product.

III. POPULATION SUBMODEL

A. Fertility Rates

The main factors affecting fertility rates are female labor force participation rate, per capita disposable income, education, mortality rate, and urbanization.

1. Effects of Female Labor Force Participation Rate

The labor force participation rate of a population is defined as the proportion of the population which is either working or looking for jobs. Because child-care is time-intensive and is usually carried out by women, the opportunity cost of a woman's time is important in determining the number of childbearings. If a woman can get a job outside the home, salary must be foregone if she chooses to have more children; hence, a working woman may tend to reduce her fertility rate and to shorten her child-spacing so that she can have more time in the labor force [92] [20]. The lower fertility rate of a working woman may also be due to the fact that a higher female labor force participation rate encourages life styles in which children play a less important role. Therefore, other things being equal, an increase in age-specific female labor force participation rates is expected to lower the age-specific fertility rates in ages 30-49 (later years of childbearing). However, whether the increase in age-specific female labor force participation rates lowers the age-specific fertility rates in ages 20-29 (early years of childbearing) depends on the net result of the positive effect of the shorter interval between births and the negative effect of fertility reduction.

2. Effects of Per Capita Disposable Income

According to the transitional hypothesis of differential fertility formulated by Cho and others [10], traditional, transitional, and post-transitional populations exhibit, respectively, a more or less positive, an inverse, and a slightly positive relationship between fertility and income.

There is a certain level of income below which (1) stillbirth rates are greater, (2) miscarriage rates are probably higher, (3) degree of involuntary abstinence is probably higher because of ill health or sickness, and (4) fecundity is probably lower because of malnutrition and the hard conditions of life. These factors may explain the more or less positive relationship between fertility and income in a traditional population. As income increases, women have better living conditions and greater access to medicine and public health services; therefore, stillbirth rates, miscarriage rates, and the degree of involuntary abstinence may be lower, and fecundity may be higher. Analyzing the detailed reproductive and nutritional-status data from 400 rural Guatemalan women, Bongaarts and Delgado [6] conclude--and their findings agree with those of previous investigations--that there is a positive relationship between nutritional status and fertility in traditional populations.

Economic development may also lead to a decline in the economic value of children; couples with higher incomes have a greater ability to support themselves without having to depend on child labor. Moreover, couples with higher income have a greater ability to choose sources of satisfaction other than having children [10]. Hence, a negative relationship between fertility and income appears in a transitional population.

In the post-transitional era, there are such small differences among the levels of most factors affecting fertility that change in income rarely affects fertility. However, there is a slight, positive relationship between fertility and income, which may be the result of the increased ability to support the children. Cho and others [10] have found evidence that higher-income families have higher fertility than middle-income families.

3. Effects of Education

An increase in female education tends to change women's attitudes toward their traditional role as homemakers and as bearers and rearers of children [113] and encourages life styles in which children play a relatively less important role. In addition, increased female education raises women's earning power and therefore increases the income foregone by having more children [94]. Education aids in the distribution of contraceptive knowledge and thus increases contraceptive efficiency. Also, education competes with other activities including marriage, implying delayed marriage. Hermalin [49] finds from his empirical research in Taiwan that fertility decreases as education increases. In addition, Chang [8] has pointed out that fertility is negatively related to the mother's education. The children desired by Taiwanese mothers with 0, 1-6, 7-9, 10-12, and more than 13 years of education are 3.81, 3.45, 3.24, 3.00, and 2.85, respectively.

Arnold also finds from his studies for Taiwan [2] [3] that couples with higher education levels desire and have fewer children. He points out that, "Although more highly educated couples exhibit more 'modern' fertility attitudes and behavior than others, we also know that well-educated individuals generally come from relatively high socio-economic status backgrounds. Under these circumstances, it is difficult to determine whether education or background is the real causal force behind educational differentials in fertility. One cannot really tell from the data [of the Economic Correlates of Fertility Survey in Taiwan in 1969] whether increases in education would really affect fertility if background factors did not change" [3, p. 2]. Therefore, we do not include education in our model because its effect is uncertain.

4. Effects of Mortality Rate

Lower infant mortality may lead to lower fertility. The papers presented at the Seminar on Infant Mortality in Relation to the Level of Fertility organized by the Committee for International Co-ordination of National Research in Demography and the three papers on this topic presented at the International Population Conference [39] [116] [96] contain evidence that a decline in child mortality leads to a decline in fertility. Specifically, Heer and Wu [48] confirmed from their surveys in Taiwan and Morocco that "the occurrence of child death among the first three births serves to increase later fertility."

Briefly, infant mortality has four principal effects on fertility [75]:

(1) Replacement Effect. If couples desire to have a certain number of surviving children, additional births may be attempted to replace the lost child.

(2) Insurance Effect. Anticipating high and varied infant mortality in the family and in the society at large, couples may feel the need to over-produce to avoid risks of loss.

(3) Biological Effect. The period of lactation is shortened by an infant death; as a result, the period of post-partum amenorrhea and abstinence is reduced, and fertility is increased, other things being equal.

(4) Societal Effect. There are many different societal responses to child mortality which are related to fertility in complex ways.

A drop in adult mortality may also reduce fertility because the slower discharge of elderly people from the labor force may cause employment difficulties for those in the reproductive ages. In addition, a greater survival rate of the elderly increases the dependency burden on the young and, thus, discourages fertility [113].

5. Effects of Urbanization

In general, fertility is lower in urban than in rural areas maybe because "secularization, secondary group association, increased segmentation of roles and poorly defined norms characterize urbanism as a way of life" [113, p. 91]. In Taiwan the number of children desired by residents of country, township, and city is 3.84, 3.52, and 3.26 respectively [8].

6. Effects of Family Planning Program

The family planning program in Taiwan was expanded in 1964 [104]. Its main objective is to reduce fertility. There are a number of evaluation studies which conclude that the program has succeeded in accelerating fertility decline beyond the secular trend. There are also some criticisms of the effectiveness of the program.

In the simulation, at first we apply the age-specific fertility equations to derive fertility rates. We set the fertility rate constant after the net reproduction rate reaches about 1,000, because we assume that Taiwan, at that time, is in the post-transitional era in which it is impossible to interpret differential fertility only in terms of variables such as "income, occupation, and education" [10, p. 300].

Our equations for age-specific fertility rates are

$$F_k = f_k\left(\frac{YD}{P}, LP_k^f, M_o, U, \frac{G_F}{P_{15-49}^f}\right) \quad k = \text{age groups } 15\text{-}19,\ 20\text{-}24,\ \ldots,\ 45\text{-}49$$

where $\frac{YD}{P}$ = per capita disposable income

LP_k^f = female age-specific labor force participation rate

M_o = infant mortality

U = urbanization

$\frac{G_F}{P^f_{15-49}}$ = government expenditure of family planning program per childbearing-age woman.

B. Survival Rates

The factors affecting mortality can generally be classified as being of two kinds: (1) those related to economic and social development, and (2) those associated with innovations in public health programs [1] [109] [111] [113]. In developed countries in the late nineteenth and early twentieth centuries, the factor responsible for the decline in mortality was economic development, which facilitates the development of new medical and public health technologies. These in turn accelerated the mortality decline in the twentieth century [113] [43].

Social and economic development may be a sufficient condition for mortality reduction, but not a necessary condition [13] [43]. During the past several decades, mortality in developing countries has been declining at an unprecedented pace. Excepting the results of economic development, the declines have been chiefly attributable to the importation and use of public health measures and medicine [13] [43] [113].

Survival rates are also affected by education, industrialization, urbanization, fertility, and so forth. Education may affect mortality rates of infant and young children because education influences the methods with which mothers feed and take care of babies [1]. Moreover, education may affect mortality rates in adult and old age groups because people with higher education levels may know more about how to take care of themselves.

Higher fertility rates may increase infant mortality rates because the rates of stillbirths, perinatal and neonatal mortality are, in general, greater for higher birth orders [113]. A woman giving birth faces higher risks of death; consequently, a higher fertility rate may lead to a higher female mortality rate in the childbearing ages.

The regression equations are of the form:

$$S_k^i = f_k^i \left(\frac{C_F}{P}, \frac{G_H}{P}, E, F\right) \qquad i = \begin{cases} 1 & \text{male} \\ 2 & \text{female} \end{cases}$$

k = age groups 0, 1-4, 5-9, ..., 75-79

where $\frac{C_F}{P}$ = per capita food consumption

$\frac{G_H}{P}$ = per capita government health expenditure

E = education

F = fertility

C. Labor Force Participation Rates

DaVanzo [20] discerns two effects of children on female labor force participation. First, "the income effect"--children increase the familial financial burden, and therefore increase the need for the woman to work to supplement family income. Second, "the substitution effect"--an increase in childbearing leads to greater female responsibilities at home. These responsibilities mean greater opportunity cost of working outside the home, and, thus, lower labor force participation rate. However, the net effects of the two are unclear.

As a child's age increases, his consumption grows; consequently, the income effect becomes more important. On the other hand, as a child's age grows, the care needed for him decreases; hence, the substitution effect becomes less important.

A mother may stay home to take care of children before they go to school, so female labor force participation rate is partially affected by past fertilities.

Mincer [62] considers the choices of people to be between work and leisure. He views demand for leisure time as a consumption of superior goods. The price of leisure is the foregone wage. There are two effects of a change in the wage rate. First, there is the substitution effect. An increase in the real wage rate means leisure is more expensive, and hence causes less consumption of leisure; that is, more work. Second, there is the income effect. A rise in the real wage rate increases real income, hence leads to more consumption of leisure; that is, less work. But which of the two effects dominates is unclear [89].

As real income increases, adult males in the United States reduce hours worked per day or per week, while their labor force participation rate remains the same or even rises [62]. This situation has not happened in Taiwan because the wage rate is so low that the supply curve of labor is still far away from the stage of "backward-bending." Labor force participation rate of young males may decline as wages grow because a family depends less on child labor and can afford to have children stay in school longer--the income effect dominates the substitution effect. When the real wage improves, elderly people can have more savings with which to retire earlier.

Education may increase labor force participation because education raises the relative employment opportunities and enlarges potential earnings and hence the opportunity cost of economic inactivity. On the other hand, education may reduce labor force participation because (1) among the young, education competes with work, and (2) people with higher education may raise wage and occupational expectations so that they may refuse low-pay, low-status, or informal jobs [97]; this may explain the fact that, in Taiwan, both female and male labor force participation rates for those with higher education levels (senior high school, senior vocational school excluding senior normal school, college, and graduate school) are generally lower than for those with lower education levels (self-education, primary school, junior high school, and junior vocational school). Labor force participation rate for the illiterate is lower than for almost any other educational level, possibly owing to lack of employment opportunities.

The age-specific female labor force participation rates are determined in the model by functions of the form

$$LP_k^f = f_k^f\,[WAG,\ F_k + (F_k)_{-1} + (F_k)_{-2} + (F_k)_{-3}] \quad k = \text{age groups } 15\text{-}19,\ 20\text{-}24,\ \ldots,\ 65\text{-}69$$

where WAG = real wage rates

$(F_k)_{-i}$ = age-specific fertility rate, lagged i years.

Also, the age-specific male labor force participation rates are of the form

$$LP_k^m = f_k^m\ (WAG)$$

where WAG = real wage rate.

D. Population Projection Identities

The component method of population projections is applied to project the future population, using the data of sex ratio at birth, age-specific fertility rates, age- and sex-specific survival rates, and base population.

Projected Female Population Identities are as follows:

$${}_5P_0^{f,\ q+5} = \frac{1}{1 + s}\ S_B^f \sum_{x=15}^{45} \left(\frac{{}_5P_x^{f,\ q} + {}_5P_x^{f,\ q+5}}{2}\right) {}_5F_x$$

$${}_5P_{x+5}^{f,\ q+5} = {}_5P_x^{f,\ q}\ \ {}_5S_x^f \qquad x = 0, 5, 10, \ldots, 75$$

$$P_{85+}^{f,\ q+5} = P_{80}^{f,\ q} \times {}_5S_{80}^f + P_{80+}^f \times {}_\infty S_{85+}^f$$

where ${}_nP_x^{f,\ q}$ = female population of ages x to x+n at the end of year q (millions of persons)

S_B^f = female survival rate from birth to ages 0-4

${}_5S_x^f$ = proportion of the female population x to x+4 years of age which will survive 5 years

${}_5S_{80}^f$ = proportion of the female population 80 to 84 years of age which will survive 5 years

${}_\infty S_{85+}^f$ = proportion of the female population 85 years and over which will live another 5 years.

Projected Male Population Identities are

$${}_5P_0^{m,\ q+5} = \frac{s}{1 + s}\ S_B^m \sum_{x=15}^{45} \left(\frac{{}_5P_x^{m,\ q} + {}_5P_x^{m,\ q+5}}{2}\right) {}_5F_x$$

$${}_5P_{85+}^{m,\ q+5} = {}_5P_x^{m,\ q}\ \ {}_5S_x^m \qquad x = 0, 5, 10, \ldots, 75$$

$$P_{85+}^{m,\ q+5} = P_{80}^{m,\ q} \times {}_5S_{80}^m + P_{85+}^{m,\ q} \times {}_\infty S_{85+}^m$$

where ${}_nP_x^{m,\ q}$ = male population of ages x to x+n at the end of year q (millions of persons)

S_B^m = male survival rate from birth to ages 0-4

${}_5S_x^m$ = proportion of the male population x to x+4 years of age which will survive 5 years

$_5S^m_{80}$ = proportion of the male population 80 to 84 years of age which will survive 5 years

$_\infty S^m_{85+}$ = proportion of the male population 85 years and over which will live another 5 years.

The steps of population projection briefly are [114]:

(1) To project the population in the first age group, we apply the projected age-specific fertility rates to the projected female population for a given year to obtain the "expected" number of total births for that year (for all series); next we average the births for the first and last years of each quinquennium, and multiply by five to secure births for a 5-year period; we multiply the births for a 5-year period by proportion of each sex at birth to obtain the births for each sex; and finally we multiply the numbers of births by the survival rates for the corresponding periods to obtain the estimate of survivors aged 0-4 at the end of each period.

(2) To project the population in the other age groups, we multiply the number of people in each age-sex group by the survival ratio for the corresponding group to obtain the estimate of population in the next higher age group for the end of the next period.

E. Equivalent Adult Consumers

In Taiwan, where food is the major item of consumption, we expect that males in general consume more than females, and that persons of working ages consume more than those of other ages. However, there are few reliable findings on the age composition of consumption. Mueller [65] has pointed out the difficulties in measuring the consumption unit scales; she states that, "If income is correlated with number of living children or with age of parents, the differences in consumption expenditures observed among couples with differing numbers and ages of children may be due partly to income effects." Parents may change their consumption behavior as family size and ages of children change. And there are economies of scale; for instance, Espenshade [28] studies the cost of children in the urban United States and finds that the second child costs about half as much as the first.

This study will mainly follow the consumption unit scales estimated by Lorimer, who bases his findings on data from India (1950) and the United States (1950's), and who intends to apply them to developing countries [65]. These estimates do not consider the possibility of a decrease in consumption as age increases. Mueller [65] argues that in a developing country, where food consumption dominates the budget, some decrease in consumption with advancing age is likely. The consumption unit scales for people aged 55 and over are taken from the estimates by Mueller.

TABLE 2.1

CONSUMPTION UNIT SCALES

Age	Males	Females
0-4	0.32	0.32
5-9	0.52	0.48
10-14	0.82	0.68
15-19	1.00	0.80
20-54	1.00	0.80
55-59	0.90	0.72
60-64	0.80	0.64
65 and over	0.70	0.56

The number of equivalent adult consumers is a weighted sum of the population in each age-sex group, with the weights varying according to the consumption differentials by age and sex:

$$P^* = \sum_{i=1}^{2} \sum_{k=1}^{18} w_k^i \, P_k^i \qquad i = \begin{cases} 1 & \text{male} \\ 2 & \text{female} \end{cases}$$

where w_k^i = weight for age group k and sex i

P_k^i = number of people in age group k and sex i

F. Total Population and Labor Force Identities

The total population is simply the sum of the population in each age-sex group:

$$P = \sum_{i=1}^{2} \sum_{k=1}^{18} P_k^i \qquad i = \begin{cases} 1 & \text{male} \\ 2 & \text{female} \end{cases}$$

P_k^i = number of people in age group k and sex i.

The total labor force is calculated by applying the age- and sex-specific labor force participation rates to the population in the corresponding age-sex group. The labor force identity, then, can be written as

$$L = \sum_{i=1}^{2} \sum_{k=4}^{14} P_k^i \, LP_k^i \qquad i = \begin{cases} 1 & \text{male} \\ 2 & \text{female} \end{cases}$$

where P_k^i = number of people in age group k and sex i

LP_k^i = labor force participation rate in age group k and sex i.

IV. ECONOMIC SUBMODEL

A. Production Function

The heart of the model is a Cobb-Douglas production function, of the form:

$$Y = e^{a}K^{*b}L^{c}$$

where K^* = end-of-year capital stock

L = labor force

a = statistical constant

b = exponent representing elasticity of Y with respect to K

c = exponent representing elasticity of Y with respect to L.

If capital and labor increase simultaneously, the increase in product depends on the sum of the exponents b and c. If the sum equals 1, there are constant returns to scale. Similarly, if the sum is greater or less than 1, there are increasing or decreasing returns to scale.

Savings are assumed to be directly channeled into investment regardless of the level of capital stock. Gross domestic capital formation is the sum of gross domestic savings, and U.S. aid, foreign capital, and loans.

$$S = Y - (C_F + C_N) - G_c - EX + M$$

$$I = S$$

where C_F = private consumption of food

C_N = private consumption of non-food

G_c = total government consumption expenditures

EX = exports

M = imports

Because most investments do not start to contribute to gross domestic product (GDP) until after a few years because of the time involved in planning and construction, it is not entirely accurate to use midyear or end-of-year capital stock in the production function as most econometric models do. If we use the effective capital input $K^* = K_{-2} + 0.4 \times (I - D) + 0.8 \times (I_{-1} - D_{-1})$, reflecting an average time of 15 months from the start of construction to completion, which Mayer's study [60] found for almost all companies in the United States, we get an unreasonable <u>ex post</u> forecast error of GNP--more than 10%. This is probably due to two reasons: (1) the average time needed for construction in Taiwan is longer than in the United States, and (2) the large increase in capital stock in 1974 and 1975 was still not productive in 1976 and 1977. For this reason, we use the following effective capital input

$$K^* = K_{-4} + 0.1 \times (I - D) + 0.2 \times (I_{-1} - D_{-1}) + 0.4 \times (I_{-2} - D_{-2}) + 0.8 \times (I_{-3} - D_{-3})$$

where D = depreciation.

B. <u>Private Consumption</u>

Most of the recently completed econometric models, e.g., the Brookings econometric model of the United States and Evans' econometric model of the Israeli economy, disaggregate the consumption into durable goods, food, other nondurables, services and the like [100] [32]. In this study, private consumption is disaggregated into food and nonfood for the following two reasons: (1) the marginal propensity to consume is assumed to be different for food and nonfood; and (2) consumption of food affects nutrition and, thus, life expectancy. Purchasing patterns are different for food and nonfood. The purchase of durables, which compose a large proportion of nonfood, is determined by prior stocks and can be easily postponed or the items can be accumulated; purchases of food, however, usually must be made at regular intervals [30]. The preceding two models and Sigit's model for Indonesia [93] all show that the marginal propensities to consume food and nonfood are different.

The theoretical role of the lagged term in the consumption function is to represent the permanent income hypothesis and the habit hypothesis. In the habit hypothesis, Brown [7] argues that the present consumption depends on the present income and the consumption level established during the last period. The permanent income hypothesis suggests that present consumption depends, not directly on the present income, but rather on permanent income [40]. If permanent income is estimated by a declining weighted average of present and past income, a Koyck transformation [55] on the present consumption function transforms the function into one with present income and a lagged consumption.

Private disposable income is expected to have a positive effect on food consumption. We also introduce a population variable in terms of the number of equivalent adult consumers. Our equation for food consumption is

$$C_F = f\ (YD,\ P^*,\ (C_F)_{-1})$$

where YD = private disposable income

P^* = number of equivalent adult consumers

$(C_F)_{-1}$ = lagged private consumption of food.

On the other hand, the private consumption of nonfood is assumed to be a function of private disposable income, the number of equivalent adult consumers and lagged private consumption of nonfood. The relationship is of the form

$C_N = f\ (YD,\ P^*,\ (C_N)_{-1})$

where YD = private disposable income

P^* = number of equivalent adult consumers

$(C_N)_{-1}$ = lagged private consumption of nonfood.

C. Government Consumption Expenditures

The government consumption expenditures are a function of the gross national product and total population. It is argued by Ogawa [70] that, when the population increases, more government services are needed. He is also concerned with the effects of aging on government pension schemes. His demographic-economic model even includes a pension submodel. However, in Taiwan, government consumption expenditure on social security and welfare services were only US$639,000 in 1975 [81], or about 2.5% of the total government consumption expenditures. Such low government consumption expenditure on social security and welfare service is not due to lack of potential recipients, but due to lack of government pension schemes. Consequently, it is not necessary to have an equation or submodel for government pensions. The equation for the government consumption expenditures is, then, of the form

$G_c = f(Y,\ P)$

where Y = gross national product

P = total population

D. Depreciation

Depreciation is seen to depend on the size of the capital stock. The function is hypothesized to be

$D = f\ (K_{-1})$

where K_{-1} = beginning-of-year capital stock.

E. Imports

One would expect gross national product to be an important determinant of imports. Some econometric models which consider imports as only a function of disposable income fail to take into account the import demand of the government sector.

The theoretical role of the lagged term in the import function is to represent the permanent income hypothesis and the habit hypothesis, as in the private consumption function. Thus, the proposed function is

$$M = f\ (Y, M_{-1})$$

where Y = gross national product

M_{-1} = lagged imports.

F. Exports

We expect that exports depend on world economy, relative prices, exchange rates, the number of equivalent adult consumers, and trade policies of our own and foreign countries. As a result, a long-run forecast of exports is impossible because of the difficulties in forecasting the world economy, relative prices, exchange rates, and our own and foreign governments' policies related to international trade.

For economic and political reasons, the Taiwan government has tried to promote exports so that they equal, or slightly exceed, imports. Thus, for our long-run simulation, we explain exports by relating them to imports. Thus, the function proposed is

$$EX = f\ (M)$$

where M = imports.

G. Wage Rate

We expect that real wage rate is positively related to average productivity of labor--output per worker. Our equation thus takes the form

$$WAG = f\ (\frac{Y}{L})$$

where $\frac{Y}{L}$ = output per worker.

H. Government Revenues

About 80% of government revenues comes from taxes. We use gross national product as the tax base. The equation for taxes is thus of the form

$$TAX = f\ (Y)$$

where Y = gross national product.

Other government revenues include household current transfers to government, government income from property and entrepreneurship, and so forth. We formulate other government revenues as a function of private disposable income. Our equation is

$$G_o = f\ (YD)$$

where YD = private disposable income.

I. Other Identities

Government revenues are the sum of taxes and other government revenues. We assume that government consumption expenditures and government investment are constrained by the sum of government revenue plus net government borrowing. The data of private disposable income include savings of private enterprises; therefore, to obtain the amount of disposable income, we simply subtract government revenue and depreciation, which do not accrue to the private sector, from GDP. The identities in the economic submodel are as follows:

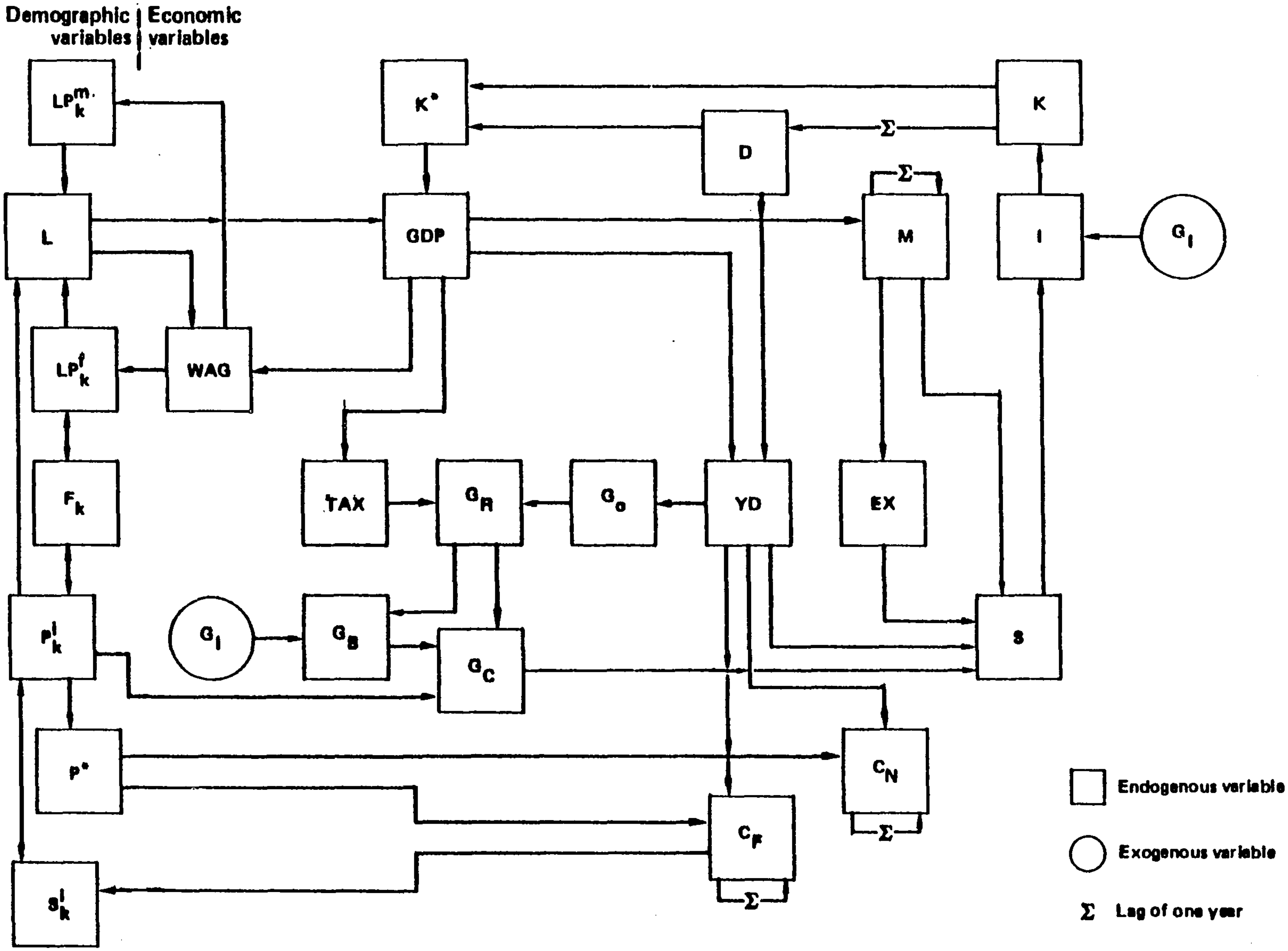
$$G_R = TAX + G_o$$

$$G_B = G_c + G_I - G_R$$

$$YD = Y - G_R - D$$

To sum up, the model consists of 118 equations--74 behavioral equations and 44 identities--involving a high degree of interrelationship among the variables (Figure 2.2). The model satisfies the mathematical criterion of completeness because in the system there are the same number of equations as there are endogenous variables.

FIGURE 2.2 INTERACTIONS BETWEEN DEMOGRAPHIC AND ECONOMIC VARIABLES



CHAPTER 3

ESTIMATION OF THE MODEL

I. METHODS

The equations of production, fertility rates, and labor force participation rates were estimated by using yearly data for the sample period 1965-1975; other equations were estimated on the basis of the period 1953-1975. To avoid the effect of variations in prices, we deflated all the economic variables by the appropriate price indices (1971 = 100). The economic variables are all in billions of 1971 N.T. dollars except per capita food consumption and per capita gross domestic product (GDP), which are in thousands of 1971 N.T. dollars. Labor force, population, and the number of equivalent adult consumers are in millions of persons.

Because the depreciation equation does not contain any unlagged endogenous variables, it was sufficient to estimate the equation by using ordinary least squares to obtain the best linear unbiased estimator. But all the other behavioral equations were estimated using two-stage least-squares (2SLS). In our model, because the number of observations is smaller than the number of predetermined variables, we could not directly apply 2SLS [54] [63] [36] [105]. To apply 2SLS, we replaced the 33 predetermined variables by nine principal components in the first stages.[1] Together, these principal components account for more than 99.8% of the total variance of the predetermined variables.

II. EMPIRICAL RESULTS

The estimated equations of the model are shown below. Although the standard test statistics are not applicable in the two-stage least-squares estimation because of the vague degrees of freedom [22], the *t* ratios are shown in parentheses below the estimated coefficients. For each equation, we also report the R^2, standard error of the regression (SER), and *F* statistic.

A. Population Submodel

TABLE 3.1

AGE-SPECIFIC FERTILITY RATES

$$F_k = a_{0k} + a_{1k}\ (YD/P) + a_{2k}\ LP_k^f + e_k$$

Age	Constant	$\frac{YD}{P}$	LP_k^f	R^2	SER	F(2,8)
(1) 15-19	69.5	- 0.814 (- 1.2)	.44 (- .35)	.52	2.57	3.8
(2) 20-24	367.9	-11.96 (- 5.4)	.04 (.04)	.93	8.5	44.6
(3) 25-29	441.4	-14.20 (- 4.1)	.14 (.07)	.90	11.7	32
(4) 30-34	314.4	-13.699 (- 5.2)	- .5 (- .4)	.93	10.3	10.3
(5) 35-39	183.7	- 6.48 (- 2.9)	-1.35 (-1.5)	.93	6.7	45.3
(6) 40-44	78.1	- 2.96 (- 2.2)	- .6 (-1.34)	.90	3.9	32
(7) 45-49	12.1	- .485 (- 2.2)	- .099 (.97)	.88	.64	26.5

Definitions of Variables:

F_k = age-specific fertility rate (%), see [85] [9].

$\frac{YD}{P}$ = per capita disposable income (thousands of 1971 N.T. dollars) [81] [85] [9].

LP_k^f = female age-specific labor force participation rate (%) [107].

TABLE 3.2

AGE-SPECIFIC FEMALE SURVIVAL RATES

$L_n S_k^f = a_{0k} + a_{1k} \, Ln \, (C_F/P) + e_k$

Age	Constant	$Ln \frac{C_F}{P}$	R^2	SER	F(1,15)
(8) 0	-0.1258	0.0654 (15.5633)	0.9413	0.0028	240.490
(9) 1-4	-0.0118	0.0077 (8.4646)	0.8241	0.0006	70.2770
(10) 5-9	-0.0097	0.0050 (12.0141)	0.9053	0.0003	143.465
(11) 10-14	-0.0093	0.0045 (7.2203)	0.7793	0.0004	52.9674
(12) 15-19	-0.0155	0.0077 (12.8675)	0.9176	0.0004	167.072
(13) 20-24	-0.0190	0.0095 (14.9110)	0.9734	0.0004	224.715
(14) 25-29	-0.0219	0.0106 (14.4706)	0.9340	0.0005	212.291
(15) 30-34	-0.0259	0.0117 (10.1311)	0.8727	0.0008	102.834
(16) 35-39	-0.0312	0.0130 (10.1210)	0.8730	0.0009	103.096
(17) 40-44	-0.0381	0.0142 (20.2619)	0.9650	0.0005	413.857
(18) 45-49	-0.0496	0.0160 (13.3580)	0.9226	0.0008	178.713
(19) 50-54	-0.0769	0.0256 (11.7053)	0.9017	0.0015	137.634
(20) 55-59	-0.1317	0.0479 (14.4642)	0.9333	0.0022	209.753
(21) 60-64	-0.1955	0.0628 (8.7816)	0.8385	0.0048	77.8869
(22) 65-69	-0.2861	0.0746 (8.0284)	0.8096	0.0062	63.7907
(23) 70-74	-0.4472	0.1057 (7.2505)	0.7753	0.0098	51.7589
(24) 75-79	-0.4619	0.3238 (4.4227)	0.5631	0.0491	19.3356

TABLE 3.2 (Cont.) Age-Specific Female Survival Rates

Definitions of Variables:

S_k^f = age-specific female survival rate, see [85] [9].

$\frac{C_F}{P}$ = per capita food consumption (thousands of 1971 N.T. dollars) [81] [85] [9].

TABLE 3.3

AGE-SPECIFIC MALE SURVIVAL RATES

$L_n\ S_k^m = a_{0k} + a_{1k}\ Ln\ (C_F/P) + e_k$

Age	Constant	$Ln \frac{C_F}{P}$	R^2	SER	F(1,15)
(25) 0	-0.1389	0.0679 (11.4289)	0.8974	0.0039	131.146
(26) 1-4	-0.0082	0.0054 (4.3969)	0.8315	0.0005	69.1011
(27) 5-9	-0.0085	0.0035 (5.4359)	0.9371	0.0002	208.578
(28) 10-14	-0.0072	0.0018 (2.1115)	0.8276	0.0002	67.2282
(29) 15-19	-0.0116	0.0028 (4.3680)	0.5604	0.0004	19.1128
(30) 20-24	-0.0149	0.0037 (9.1579)	0.8505	0.0003	85.3569
(31) 25-29	-0.0185	0.0051 (13.0473)	0.9221	0.0003	177.632
(32) 30-34	-0.0252	0.0076 (7.4757)	0.7892	0.0007	56.1662
(33) 35-39	-0.0360	0.0116 (7.5597)	0.7943	0.0002	57.9310
(34) 40-44	-0.0519	0.0167 (8.6115)	0.8321	0.0013	74.3189
(35) 45-49	-0.0804	0.0269 (12.4176)	0.9115	0.0015	154.557
(36) 50-54	-0.1245	0.0401 (2.2143)	0.2826	0.0121	5.9094
(37) 55-59	-0.2361	0.0945 (4.4766)	0.5488	0.0142	18.2480
(38) 60-64	-0.3273	0.1121 (13.2161)	0.9204	0.0057	173.520
(39) 65-69	-0.4608	0.1350 (12.9505)	0.9174	0.0070	166.491
(40) 70-74	-0.6665	0.1760 (8.5787)	0.8294	0.0138	72.9090
(41) 75-79	-1.0296	0.5631 (2.7415)	0.3240	0.1378	7.1886

TABLE 3.3 (Cont.) Age-Specific Male Survival Rates

Definitions of Variables:

S_k^m = age-specific male survival rate, see [85] [9].

$\frac{C_F}{P}$ = per capita food consumption (thousands of 1971 N.T. dollars) [81] [85] [9].

TABLE 3.4

AGE-SPECIFIC FEMALE LABOR FORCE PARTICIPATION RATES

$$\text{Ln } LP^f_k = a_{0k} + a_{1k} \text{ Ln } [F_k + (F_k)_{-1} + (F_k)_{-2} + (F_k)_{-3}] + a_{2k} \text{ Ln WAG} + e_k$$

Age	Constant	Ln $[F_k + (F_k)_{-1} + (F_k)_{-2} + (F_k)_{-3}]$	Ln WAG	R^2	SER	F(2,8)
(42) 15-19	3.6454	-0.0138 (-0.0546)	0.0980 (1.3450)	0.3540	0.0280	1.9177
(43) 20-24	2.0253	-0.2405 (-0.7422)	0.4638 (1.7894)	0.6840	0.0607	8.6600
(44) 25-29	6.0298	-0.6100 (-1.1787)	0.2326 (0.5049)	0.6041	0.0861	6.1034
(45) 30-34	1.9177	-0.2429 (-0.7401)	0.4176 (0.6372)	0.6038	0.1016	6.0958
(46) 35-39	5.0331	-0.3002 (-1.7676)	0.0349 (0.0626)	0.7832	0.0762	14.4540
(47) 40-44	3.8019	-0.2266 (-0.8545)	0.2225 (0.2703)	0.8021	0.08817	16.2108
(48) 45-49	2.0984	-0.1919 (-0.6991)	0.5044 (0.4827)	0.8052	0.0796	14.4713 F(1,9)
(49) 50-54	-4.5343		1.0219 (3.5117)	0.5747	0.1161	12.1591
(50) 55-59	-7.3749		1.3357 (3.8216)	0.6166	0.1395	14.4730
(51) 60-64	3.1014		-0.1782 (-0.2998)	0.0104	0.2372	0.0944
(52) 65-69	9.8315		-1.2483 (-1.7690)	0.2563	0.2817	3.1016

Definitions of Variables:

LP^f_k = age-specific female labor force participation rate (%), see [107].

$(F_k)_{-i}$ = age-specific fertility rate, lagged i years (%) [85] [9].

WAG = real wage rates (1971 N.T. dollars) [80] [83] [81].

TABLE 3.5

AGE-SPECIFIC MALE LABOR FORCE PARTICIPATION RATES

$\text{Ln } LP_k^m = a_{0k} + a_{1k} \text{ Ln WAG} + e_k$

Age	Constant	Ln WAG	R^2	SER	F(1,9)
(53) 15-	8.2408	-0.5663 (-6.3129)	0.8177	0.0358	40.3724
(54) 20-	5.8799	-0.1980 (-2.6824)	0.4629	0.0295	7.7568
(55) 25-	4.8304	-0.0340 (-2.8661)	0.7677	0.0047	29.7381
(56) 30-	4.5426	0.0059 (0.6567)	0.8838	0.0036	68.4311
(57) 35-	4.4564	0.0175 (2.4399)	0.9054	0.0029	86.0925
(58) 40-	4.4140	0.0221 (1.9830)	0.8062	0.0044	37.4323
(59) 45-	4.3182	0.0316 (2.3461)	0.6953	0.0054	20.5325
(60) 50-	3.0899	0.1878 (2.1961)	0.3735	0.0341	5.3658
(61) 55-	1.9635	0.3144 (4.1741)	0.6659	0.0301	17.9416
(62) 60-	3.3373	0.0677 (0.2622)	0.0144	0.1031	0.1314
(63) 65-	16.6273	-1.8433 (-4.9000)	0.7257	0.1501	23.8123

Definitions of Variables:

LP_k^m = age-specific male labor force participation rate (%), see [107]

WAG = real wage rates (1971 N.T. dollars) [80] [83] [81].

Projected Female Population Identities

(64) $${}_5P_0^{f,\ q+5} = \frac{1}{1+s}\ S_B^f \sum_{x=15}^{45} \frac{({}_5P_x^{f,\ q} + {}_5P_x^{f,\ q+5})}{2}\ {}_5F_x$$

(65-80) $${}_5P_x^{f,\ q+5} = {}_5P_x^{f,\ q}\ {}_5S_x^f \qquad x = 0, 5, 10, \ldots, 75$$

(81) $$P_{85+}^{f,\ q+5} = P_{80}^{f,\ q} \times {}_5S_{80}^f + P_{85+}^{f,\ q} \times {}_\infty S_{85+}^f$$

Projected Male Population Identities

(82) $${}_5P_0^{m,\ q+5} = \frac{s}{1+s}\ S_b^f \sum_{x=15}^{45} \frac{({}_5P_x^{m,\ q} + {}_5P_x^{m,\ q+5})}{2}\ {}_5F_x$$

(83-98) $${}_5P_{x+5}^{m,\ q+5} = {}_5P_x^{m,\ q}\ {}_5S_x^m \qquad x = 0, 5, 10, \ldots, 75$$

(99) $$P_{85+}^{m,\ q+5} = P_{80}^{m,\ q} \times {}_5S_{80}^m + P_{85+}^{m,\ q} \times {}_\infty S_{85+}^m$$

Equivalent Adult Consumers Identities

(100) $$P^* = \sum_{i=1}^{2} \sum_{k=1}^{18} W_k^i\ P_k^i \qquad i = \begin{cases} 1 & \text{male} \\ 2 & \text{female} \end{cases}$$

Total Population

(101) $$P = \sum_{i=1}^{2} \sum_{k=1}^{18} P_k^i \qquad i = \begin{cases} 1 & \text{male} \\ 2 & \text{female} \end{cases}$$

Labor Force Identities

(102) $$L = \sum_{i=1}^{2} \sum_{k=4}^{14} P_k^i\ LP_k^i \qquad i = \begin{cases} 1 & \text{male} \\ 2 & \text{female} \end{cases}$$

B. Economic Submodel

Production Function	R^2	SER	F(k-1, N-k)
(103) $\text{Ln } Y = 0.3031 + 0.6828\ (\text{Ln } K^* + \text{Ln } L)$ (22.3869)	0.9824	0.0414	502.729

	R^2	SER	F(k-1, N-k)

Private Consumption of Food

$$(104)\quad C_F = -3.0023 + \underset{(2.9505)}{0.1436\ YD} + \underset{(1.8239)}{2.1164P^*} + \underset{(1.4589}{0.2873}\ (C_F)_{-1}$$

	R^2	SER	F(k-1, N-k)
(104)	0.9952	1.1719	973.26

Private Consumption of Nonfood

$$(105)\quad C_N = -17.2743 + \underset{(4.0132)}{0.2269YD} + \underset{(1.7201)}{1.8159P^*} + \underset{(4.226)}{0.4860}\ (C_N)_{-1}$$

	R^2	SER	F(k-1, N-k)
(105)	0.9987	1.1362	3483.86

Government Expenditures

$$(106)\quad G_c = 5.8549 + \underset{(2.0885)}{1.6721\ P} + \underset{(3.6216)}{0.0599\ Y}$$

	R^2	SER	F(k-1, N-k)
(106)	0.9736	1.4662	295.236

Depreciation

$$(107)\quad D = -4.1688 + \underset{(22.7825)}{0.0454}\ K_{-1}$$

	R^2	SER	F(k-1, N-k)
(107)	0.9629	1.4280	519.046

Imports

$$(108)\quad M = -20.9802 + \underset{(5.9935)}{0.6476}\ M_{-1} + \underset{(4.2847)}{0.2150\ Y}$$

	R^2	SER	F(k-1, N-k)
(108)	0.9883	5.1967	674.834

Exports

$$(109)\quad EX = -2.9083 + \underset{(28.2285)}{1.1132\ M}$$

	R^2	SER	F(k-1, N-k)
(109)	0.9792	7.5633	800.565

Wage

$$(110)\quad WAG = 610.2 + \underset{(8.6482)}{29.4464}\ \frac{Y}{L}$$

	R^2	SER	F(k-1, N-k)
(110)	0.8924	84.6490	74.6547

Tax

$$(111)\quad TAX = -12.7378 + \underset{(10.9893)}{0.2199\ Y}$$

	R^2	SER	F(k-1, N-k)
(111)	0.9907	1.7351	1711.32

Other Government Revenues

$$(112)\quad G_o = -4.3183 + \underset{(9.7052)}{0.1160\ YD}$$

	R^2	SER	F(k-1, N-k)
(112)	0.8424	2.9036	90.8434

Identities

$$(113)\quad S = Y - (C_F + C_N) - G_c - EX + M$$

$$(114)\quad I = S$$

(115) $K^* = K_{-4} + 0.1 \times (I - D) + 0.2 \times (I_{-1} - D_{-1}) + 0.4 \times (I_{-2} - D_{-2}) + 0.8 \times (I_{-3} - D_{-3})$

(116) $G_R = TAX + G_o$

(117) $G_B = G_c + G_I - G_R$

(118) $YD = Y - D - G_R$

C. Explanation of Symbols

1. Endogenous Variables

C_F = private consumption of food (billions of 1971 N.T. dollars), see [81].

C_N = private consumption of non-food (billions of 1971 N.T. dollars) [81].

D = depreciation (billions of 1971 N.T. dollars) [81].

EX = exports (billions of 1971 N.T. dollars) [81].

F_k = age-specific fertility rate (%) [85] [9].

G_B = net government borrowing (billions of 1971 N.T. dollars) [84].

G_c = total government consumption expenditures (billions of 1971 N.T. dollars) [81].

G_o = current transfers to government, government income from property and entrepreneurship, and so forth (billions of 1971 N.T. dollars) [84].

G_R = government revenues (billions of 1971 N.T. dollars) [84].

I = gross domestic capital formation (billions of 1971 N.T. dollars) [81].

K = end-of-year capital stock (billions of 1971 N.T. dollars) [82].

K* = effective capital input (billions of 1971 N.T. dollars).

L = midyear labor force (millions of persons) [107] [85] [9].

LP_k^f = female age-specific labor force participation rate (%) [107].

LP_k^m = male age-specific labor force participation rate (%) [107].

M = imports (billions of 1971 N.T. dollars) [81].

P = total population (millions of persons) [85] [9].

${}_nP_x^{f,\,q}$ = female population of ages x to x+n at the end of year q (millions of persons) [85] [9].

${}_{n}P_{x}^{m,q}$ = male population of ages x to x+n at the end of year q (millions of persons) [85] [9].

P* = equivalent adult consumers (millions).

S = gross domestic savings (billions of 1971 N.T. dollars) [81].

S_b^f = female survival rate from birth to ages 0-4 [85] [9].

${}_{5}S_{x}^{f}$ = proportion of the female population x to x+4 years of age which will survive 5 years [85] [9].

${}_{5}S_{80}^{f}$ = proportion of the female population 80 to 84 years of age which will survive 5 years [85] [9].

${}_{\infty}S_{85+}^{f}$ = proportion of the female population 85 years and over which will live another 5 years [85] [9].

S_B^m = male survival rate from birth to ages 0-4 [85] [9].

${}_{5}S_{x}^{m}$ = proportion of the male population x to x+4 years of age which will survive 5 years [85] [9].

${}_{5}S_{80}^{m}$ = proportion of the male population 80 to 84 years of age which will survive 5 years [85] [9].

${}_{\infty}S_{85+}^{m}$ = proportion of the male population 85 years and over which will live another 5 years [85] [9].

WAG = real wage rates (1971 N.T. dollars) [80] [83] [81].

TAX = taxes (billions of 1971 N.T. dollars) [84].

Y = gross domestic product (billions of 1971 N.T. dollars) [81].

YD = private disposable income, including savings of private enterprises (billions of 1971 N.T. dollars) [81].

2. Exogenous Variables

G_I = government investment (billions of 1971 N.T. dollars) [81].

3. Parameters

i = code number for sexes, where i = 1 for male and i = 2 for female.

k = code number for age groups, where k = 1 for ages 0-4, 2 for ages 5-9,..., 17 for ages 80-84, 18 for ages 85 and over.

q = time-index for quinquennial years (q is omitted where unnecessary).

s = sex ratio, we assume 105 males per 100 females.

w_k^i = weight varying according to the relative consumption of different age-sex groups.

III. DISCUSSION OF THE RESULTS

A. Fertility Rates

In our sample, we found that, with the exception of the government expenditure on the family planning program, the factors which affect fertility are influenced, directly or indirectly, by income and are highly correlated with one another and with income [113], raising the problem of multicollinearity. For this reason, we use per capita disposable income as proxy for these variables.

1. Effects of Labor Force Participation and Per Capita Disposable Income

Generally, our regression model accounts for more than 90% of the total variance in age-specific fertility rates.

The regression coefficients of age-specific fertility rates on age-specific female labor force participation rates are negative except for age groups 20-24 and 25-29; nevertheless, from the small coefficients and *t* statistics (approximately zero) for labor participation rates in the two age groups, we can tell that between the variables either no relationship exists, or only a slightly positive one.

The negative relationship between the two variables for females ages 15-19 may result from the working women in that age group postponing their marriages and childbearing until they are in their 20's. The working women aged over 30 may already have had the number of children they desire, and therefore have stopped their childbearing for the convenience of work, for alternative sources of satisfaction other than having children, and so forth. According to surveys, almost all Taiwanese still desire three or four living children with at least one boy [37] [38]. Even when the working women want fewer living children (e.g., three) they usually wish to bear the number of children they desire while in their 20's. For this reason, other things being equal, the female labor force participation in age groups 20-24 and 25-29 does not reduce the age-specific fertility rates in the same age groups; the slightly positive relationship which appears in these age groups indicates that the positive effect of the shorter child-spacing dominates the negative effect of fertility reduction.

The coefficients of disposable income per capita in each age group are all negative, as expected.

2. Effectiveness of Family Planning Programs

The effectiveness of family planning programs is one of the major controversies in the current literature on population policy. Taiwan has been considered one of the areas with the most successful family planning programs in the world. however, our study fails to find any significant effect of the program on fertility in Taiwan.

Liu finds in his study [57] that a positive relationship between the cumulative rates of intrauterine device (IUD) insertions and fertility rates for women aged 15-19, 20-24, and 45-49; he argues that the positive relationship happens in the former two age groups because "young mothers tend to use contraception for spacing." Liu states: "Two recent fertility surveys reveal that in 1966, 16 percent of IUD acceptors who were young and of low parity reported that they were using IUDs for the purpose of spacing, and by 1970 this proportion increased to 20 percent" [57, p. 162].

Since family planning programs allow a couple to control spacing, the couple can have the number of children they want and also have more time to participate in the labor force. Therefore, income will be increased.

It is difficult to evaluate the effectiveness of family planning programs. Using IUD acceptors as a method of evaluating the program may provide very useful information. However, to evaluate the effectiveness of a family planning program, it is not proper to use the IUD as an independent variable in a fertility equation, since we cannot tell whether couples accept IUD as a result of the program or for other reasons, such as changes in income or female labor force participation. The studies of Sun [103] [104] and of Khoo and Park [52] may have the same deficiencies because they also use the data on IUD acceptors to evaluate the effectiveness of the family planning program in Taiwan.

Sun [103] [104] analyzes fertility trends to evaluate the family planning program in Taiwan. He explains that, "If we can assume, however, that the pace of changes in factors affecting fertility, such as proportion married, adoption of fertility control measures in the absence of a program etc., was the same before and after the expansion of the program in 1964, the effect of the program on fertility should appear as an accelerated fertility decline..." [104, p. 21]. He then concludes that, "Even though the decline in marital fertility is not entirely due to the effect of the program,...The speed of decline in marital fertility after 1963 exceeds that before 1963, [and] it is possible that the family planning program has had an impact on fertility" [104, p. 25].

There is some evidence that important aspects of Taiwan's development accelerated after 1963. In Taiwan, television broadcasts began in 1962 [83], one year before the family planning program was expanded. Although movies were introduced to Taiwan earlier, they have always been much less popular than television. Television gives people access to more varieties of entertainment, to the life styles of the upper socio-economic classes, and "to education and to literature, art, science and political activity," which has been considered the most important social factor responsible for the fertility decline in the U.S.S.R. [113]. Through television, people may learn of alternative sources of satisfaction to having children and may develop more negative attitudes toward women's traditional roles as bearers and rearers of children. Chang [8] studied the relationship between the frequency of parents' access to the media for mass communication (television, radio, newspapers, magazines, and so forth) and the number of children desired. He found that the correlation coefficient is -.488; in other words, the greater the access to the media, the smaller the number of children desired. Chang excludes households which are without media. But even though a family may not have a television set, radio, newspapers, or magazines, it may still have access to them. Therefore, Chang undoubtedly underestimates the effect of mass communication.

The average annual growth rate of per capita real income, which, as we have seen, is perhaps the most important determinant of fertility, was 3.30% during the period 1953-1963 and 5.34% after 1964 (1964-1975). The pace of increase in per capita real income was clearly faster after the family planning program was expanded. Therefore, it is certainly not justifiable to assume the same pace of changes in factors influencing fertility before and after the expansion of the family planning program.

Freedman and Takeshita observe that, even before the family planning program began, almost all Taiwanese desired only three or four children with at least one boy. Before the program, the higher socio-economic status groups of Taiwanese were already practicing contraception extensively, even though they usually started late, after having more children than they wanted [38].

It cannot be claimed that the higher socio-economic status groups started contraception late because of the lack of a family planning program for at least two reasons:

(1) Because of the insurance effect, couples faced with high and varied mortality rates may produce more children than they want as an insurance against risks of loss. Parents may roughly judge mortality rates on the basis of the levels found among their family, among their friends, and in the society at large. When infant mortality declines sharply, couples may not be aware of that decline until after they have already over-produced children. When they find that infant mortality rate has not been as high as they expected, they are likely to discover that they have more children than they wanted. This situation will occur most frequently in countries in which the infant mortality rate declines rapidly. Taiwan is one of the best examples.

(2) When a couple is young, they may want a big family because of cultural, economic, or social factors. If these factors affecting ideal family size change rapidly, the couple may later decide that a small family is preferable; but by that time, they are likely to have already

produced more children than they want. This situation will occur most frequently in countries with rapid cultural, economic, or social reforms. Again, Taiwan is one of the best examples!

Hauser is not convinced that the family planning program in Taiwan has actually reduced fertility faster than the secular trend [45]. Commenting on Notestein's paper "Zero Population Growth," Hauser argues that in Taiwan, South Korea, Hong Kong, and Singapore, low fertility motivation developed from rising education and rising living standards, both of which occurred before any effective family planning programs were introduced [46].

Palmore and Park show that Israel, Australia, and New Zealand have reduced fertility to very low levels without government family planning programs. According to those authors, "They lowered fertility by the people's own choice, sometimes in the face of opposing or neutral government attitudes. The incipient decline of fertility was observed several decades ago in these countries..." [72].

Davis asserts that if couples have more children than they want, the services and methods of a family planning program will expedite a fertility decline that would occur in any case. However, where there is high fertility motivation, a family planning program is ineffective in lowering fertility because the program is poorly equipped to influence the determinants of the motivation. He also maintains that, "Popular enthusiasm for family planning is found mainly in the cities, or in advanced countries such as Japan and Taiwan, where the people would adopt contraception in any case, program or no program" [18].

Freedman and Sun [37] agree that fertility reduction in Taiwan has been caused largely by rapid social and economic progress. Furthermore, they argue that, in Taiwan, fertility declined in the 1960's mostly in response to mortality reduction. They also assert that the tradition of larger family size was undermined by education; since the 1960's, more people in Taiwan have been educated to higher levels than ever before. Besides, they point out that almost all Taiwanese still desire three or four children with no less than one boy.

According to the survey conducted by Chang in Taiwan in 1977, the workers in the salt industry desire, on the average, more than four living children; agricultural workers (including fishermen), more than 3.6; military personnel, civil servants, and teachers, 3.17 [8]. This reveals that the number of desired children varies by occupation, which is the most extensively used index of socio-economic status [113].

In Tables 3.6(1), 3.6(3), and 3.6(4) we report the results of the fertility equations which incorporate family planning expenditure per childbearing-age woman. From Tables 3.6(1) and 3.6(2), we can see that the explanatory power of income per capita is higher than that of family planning expenditure per childbearing-age woman. When we include these two variables in one equation, as in Table 3.6(3), the additional explanatory power of family planning expenditure per childbearing-age woman is not very great, and half of the coefficients have the wrong signs. Similar results are obtained if we include labor force participation rate, income per capita, and family planning expenditure per childbearing-age woman in one equation, as in Table 3.6(4). In addition, when we take into account the possibility of a lag in the effect of family planning expenditure (1 year, 2 years, 3 years, and 4 years), similar or even worse results are obtained. We also get similar results from other functional forms such as

$$(1)\ F_k = a_{0k} + a_{1k}\ \text{Ln}\ (YD/P) + a_{2k}\ \text{Ln}\ (G_F/P^f_{15-19}) + e_k,$$

$$(2)\ \text{Ln}\ F_k = a_{0k} + a_{1k}\ \text{Ln}\ (YD/P) + a_{2k}\ \text{Ln}\ (G_F/P^f_{15-19}) + e_k,\ \text{and}$$

$$(3)\ F_k = a_{0k} + a_{1k}\ (1/(YD/P)) + a_{2k}\ (1/(G_F/P^f_{15-19})) + e_k.$$

We also estimated the equations of age-specific fertility rates using stepwise inclusion so that the variable explaining the largest amount of variance in the dependent variable would be entered first [69]; the results are shown in Table 3.7. We find that, in the equation of each age group, disposable income per capita enters the equations first. As family planning expenditure per childbearing-age woman enters the equation, R^2 does not increase much. In addition, half of the signs of family planning expenditure per childbearing-age woman are positive, contradicting the main objective of the program. Accordingly, it seems clear almost all fertility decline during the sample period has been caused by an increase in per capita income and not by the family planning program.

However, the regression method cannot completely account for a potentially important lifetime impact on actual fertility. An increase in the efficiency of contraceptive methods may lead couples to shorten their child-spacing [47]. Consequently, a family planning program may actually lead to an increase in the number of children born to young women even though their lifetime childbearing will decline. Also, even if a family planning program only helps couples eliminate unwanted births, without changing their high fertility motivation, it will still substantially reduce the future population growth rate.

In short, Taiwan's family planning program may have succeeded in the distribution of contraceptive devices, information, and services; however, it may not have had any appreciable effect on the factors

TABLE 3.6

AGE-SPECIFIC FERTILITY RATES REGRESSION

(1) $F_k = a_{0k} + a_{1k} (G_F/P^f_{15-49}) + e_k$

(Sample period: 1953-1975)

AGE	CONSTANT	G_F/P^f_{15-49}	R^2	SER	F(1,20)
15-19	46.905	- 8750.97 (- 5.792)	.615	3.924	33.544
20-24	264.260	-27188.9 (- 3.178)	.325	22.220	10.099
25-29	345.229	-56428.6 (5.209)	.564	28.136	27.130
30-34	275.036	-122459 (9.358)	.807	33.986	87.574
35-39	190.769	-120743 (-10.405)	.838	30.139	108.254
40-44	88.481	-61363.6 (-10.189)	.8318	15.641	103.823
45-49	17.617	-13082.6 (- 6.288)	.652	5.403	39.545

(2) $F_k = a_{0k} + a_{1k} (YD/P + e_k)$

(Sample period: 1953-1975)

AGE	CONSTANT	$\frac{YD}{P}$	R^2	SER	F(1,20)
15-19	56.4248	- 1.6992 (- 8.2206)	.7718	2.9625	67.6578
20-24	305.907	- 6.5767 (- 7.8147)	.7524	12.0618	60.7901
25-29	409.662	-11.0522 (-15.4767)	.9224	10.2350	237.885
30-34	397.621	-22.3923 (-18.5318)	.9444	17.3180	339.742
35-39	306.089	-21.5508 (-12.2366)	.8808	25.2418	147.837
40-44	147.140	-10.9770 (-11.5495)	.8682	13.6220	131.790
45-49	30.5774	- 2.4047 (- 6.7232)	.6890	5.1263	44.3105

TABLE 3.6 (Cont.) Age-Specific Fertility Rates Regression

(3) $F_k = a_{0k} + a_{1k}\ (YD/P) + a_{2k}\ (G_F/P^f_{15-49}) + e_k$

(Sample period: 1953-1975)

AGE	CONSTANT	YD/P	G_F/P^f_{15-49}	R^2	SER	F(2,19)
15-19	56.978	-1.575 (3.946)	-1431.82 (.654)	.784	3.015	36.197
20-24	346.981	-12.935 (-15.254)	32919.4 (7.081)	.947	6.406	177.100
25-29	447.363	-15.970 (-11.862)	17787.0 (2.410)	.946	10.171	174.161
30-34	394.463	-18.674 (-9.562)	-35678.1 (-3.332)	.965	14.754	278.050
35-39	277.028	-13.488 (-4.887)	-58063.1 (-3.838)	.926	20.849	125.059
40-44	130.496	-6.569 (-4.292)	-30833.8 (-3.674)	.912	11.563	104.190
45-49	26.659	-1.414 (-2.138)	-6512.32 (-1.80)	.718	4.995	25.423

TABLE 3.6 (Cont.) Age-Specific Fertility Rates Regression

(4) $F_k = a_{0k} + a_{1k} (G/F\ P^f_{15-49}) + a_{2k} (YD/P) + a_{3k} LP^f_k + e_k$

(Sample period: 1965-1975)

AGE	CONSTANT	G_F/P^f_{15-49}	YD/P	LP^f_k	R^2	SER	F(3,6)
15-19	52.309	11919.4 (3.592)	- 1.118 (-5.240)	-.294 (-1.003)	.862	1.462	14.537
20-24	362.234	27643.7 (2.010)	-12.601 (-8.066)	-.273 (-.351)	.973	5.886	84.625
25-29	422.959	32880.3 (1.215)	-18.065 (-6.069)	.966 (.557)	.938	11.580	35.495
30-34	326.958	5882.00 (.205)	-15.646 (-5.886)	-.376 (-.274)	.942	10.887	38.081
35-39	197.505	-11489.5 (-.614)	- 8.183 (-3.662)	-.854 (-.851)	.937	7.107	34.503
40-44	91.963	-12172.4 (-1.510)	- 3.349 (-3.224)	-.498 (-1.365)	.931	3.539	31.266
45-49	15.096	- 2640.64 (-2.163)	- .336 (-1.972)	-.149 (-2.047)	.925	.533	28.795

Definitions of Variables:

F_k = age-specific fertility rate (%) [85] [9].

G_F/P^f_{15-49} = government expenditures of family planning program per childbearing-age woman (thousands of 1971 N.T. dollars) [74].

$\frac{YD}{P}$ = per capita disposable income (thousands of 1971 N.T. dollars) [81] [85] [9].

LP^f_k = female age-specific labor force participation rate (%) [107].

TABLE 3.7

AGE-SPECIFIC FERTILITY RATE REGRESSIONS, WITH STEPWISE INCLUSION

$$F_k = a_{0k} + a_{1k}\,(G_F/P^f_{15-49}) + a_{2k}\,(YD/P) + a_{3k}\,LP^f_k + e_k$$

(Sample period: 1965-1975)

DEPENDENT VARIABLE	VARIABLES	R^2	R^2 CHANGE	BETA
F_{15-19}	YD/P	.5973	.5973	- .7703
	G_F/P	.8418	.2445	.5085
	LP^f_{15-19}	.8617	.0199	- .1479
F_{20-24}	YD/P	.9576	.9576	- .9530
	G_F/P	.9727	.015	.1294
	LP^f_{20-24}	.9732	.001	- .042
F_{25-29}	YD/P	.9183	.9183	-1.0494
	G_F/P	.9356	.0173	.1183
	LP^f_{25-29}	.9383	.0027	.0980
F_{30-34}	YD/P	.9416	.9416	- .9352
	LP^f_{30-34}	.9419	.0003	- .0469
	G_F/P	.9423	.0003	- .0218
F_{35-39}	YD/P	.9166	.9166	- .7849
	LP^f_{35-39}	.9332	.0167	- .1919
	G_F/P	.9367	.0034	- .0682
F_{40-44}	YD/P	.8838	.8838	- .6754
	LP^f_{40-44}	.9121	.0283	- .1520
	G_F/P	.9306	.0185	- .2874
F_{45-49}	YD/P	.8431	.8431	- .4671
	LP^f_{45-49}	.8802	.0370	- .2274
	G_F/P	.9250	.0449	- .4835

* See Table 3.6 for the definitions of variables.

causing high fertility motivation. Information on contraceptive methods is costly; the program may help those who already want to control child-bearing by supplying them with the information they desire.

B. Survival Rates

Education, industrialization, urbanization, fertility, public health expenditure, and so forth are highly correlated with per capita income and with per capita food consumption. Hence, we use per capita food consumption as proxy for these variables.

The coefficients of per capita food consumption are all positive in each age and sex group. Our results are therefore in conformity with Adelman's conclusion that mortality rates are negatively correlated with real income per capita (food consumption per capita in our equations of survival rates) [1].

In Liu's findings in the equations of survival rates, the signs of coefficients of per capita disposable income are not uniform; they are positive for younger and older age groups but negative for the working ages [57]. This suggests that the survival rate is more closely related to per capita food consumption than to real disposable income per capita.

C. Labor Force Participation Rates

The regression coefficients of female age-specific labor force participation rates on age-specific fertility rates (current plus lagged 1, 2, and 3 years) are all negative. The negative signs of age-specific fertility rates imply that the substitution effect of children on female labor force participation rate dominates the income effect [20].

Liu also acquires negative signs except for the age group 20-24 [57], although he does not consider past fertility rates. Da Vanzo also finds a negative relationship for Chile in 1960 between female age-specific labor force participation rates and age-specific fertility rates [20].

From a cross-sectional study, Collver and Langlois also find a highly negative relationship, Pearsonian correlation -.60, between fertility and female labor force participation [15].

We use the industrial wage rates as proxy for the wage rates. In general, a positive relationship is observed between female labor force participation rates for young and adult age groups and the real wage rates, while a negative relationship appears for older age groups. On the other hand, an inverse relationship is observed between male labor force participation rates for young and older age groups and the real wage rates, while a positive relationship appears for adult age groups.

The negative coefficients for young ages indicate that couples can afford to have their children stay in school longer; the negative coefficients for older ages imply that elderly people can have more savings with which to retire earlier.

This statistical result is compatible with Standing's finding that "empirical research has so far not adequately demonstrated any consistent association between education and female labor force participation" [97, p. 295].

D. Production Function

There is no office in Taiwan responsible for regularly compiling statistics of capital stock. The yearly estimates of capital stock used for the econometric model by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan, violate the identity $K_t = K_{t-1} + I_t - D_t$; that is, the sum of the beginning-of-year capital stock and the current investment minus the current depreciation does not equal the end-of-year capital stock.[2] Applying the identity, we used the value of capital stock in 1953 and yearly values of capital formation and depreciation to obtain the yearly estimate of capital stock for our model.

Regressing gross domestic product on effective capital input and labor force, we obtained

$$\text{Ln } Y = -0.0034 + \underset{(2.2174)}{0.6910} \text{ Ln } K^* + \underset{(0.9001)}{0.6619} \text{ Ln } L$$

$R^2 = 0.9902$ SER = 0.0318 $F(2,7) = 354.127$.

Because the *t*-statistic conflicts with *F*-statistic in this equation, there is multicollinearity. To solve this problem, we constrain the parameters of K* and L and reestimate them, using the functional form:

$$\text{Ln } Y = a + b\ (\text{Ln } K^* + \text{Ln } L).$$

The equation estimated is

$$\text{Ln } Y = 0.3031 + \underset{(22.3869)}{0.6828}\ (\text{Ln } K^* + \text{Ln } L)$$

$R^2 = 0.9824$ SER = 0.0414 $F(2,7) = 502.729$

The elasticities of product with respect to capital and labor are all 0.6828. The sum of elasticities of capital and labor is 1.3656, indicating either increasing returns to scale of improvement in capital or labor.

E. Private Consumption

As expected, private disposable income, equivalent adult consumers and lagged private consumption of food are all positively related to private consumption of food; private disposable income, equivalent adult consumers and lagged private consumption of nonfood are all positively related to private consumption of nonfood.

The short-run marginal propensity to consume is 0.37. The short-run marginal propensity to consume food is 0.1436 and to consume nonfood is

0.2269. The long-run marginal propensity to consume can be calculated by assuming $C_t = C_{t-1}$; that is, consumption patterns are assumed to be the same over time [73]. Solving for $(C_F)_t = (C_F)_{t-1}$, we find that the long-run marginal propensity to consume food is 0.1436/(1 - 0.2873) = 0.20. From the same method, we find that the long-run marginal propensity to consume nonfood is 0.44. Therefore, the long-run marginal propensity to consume is 0.64.

Both the short- and long-run marginal propensities to consume in this study are lower than those from almost all other empirical studies which do not incorporate population in the consumption function; Evans' empirical findings of the long-run marginal propensities to consume for the post-war U.S. economy are about 0.83 [30]. However, our findings are compatible with recent empirical studies incorporating population in the consumption function; Liu's is 0.695 [57], and Ogawa's is only 0.367 [70]. Population is thus shown to have an important role in the determination of consumption.

F. Government Consumption Expenditures

As expected, the size of population and the level of gross national product are the major determinants of government consumption expenditures. Our result is therefore in agreement with Ogawa's finding that government consumption expenditures are highly related to population size and gross national product [70].

G. Depreciation

The estimated depreciation as percentage of capital stock in Taiwan is about 4.54%, lower than the 7.7% estimated by Ogawa [70] for Japan for the period 1951-1971. However, our estimate is higher than the 4% estimated by Sigit [93] for Indonesia for the period 1960-1972. All these results are in conformity with Clark's argument that "we should expect the simpler and more agricultural economies to have a lower depreciation rate than the more advanced industrial countries" [11]. In a developing country, labor is cheaper than capital; the maintenance cost of capital is less expensive than the price of capital. Therefore, capital in a developing country tends to be used longer than in a developed country [93].

H. Imports

Although the short-run income elasticity for imports is estimated to be only 0.22, we obtain a long-run income elasticity for imports of 0.61, by estimating the same way as for the long-run marginal propensity to consume.

I. Exports

The estimated coefficient of imports is 1.1; that is, slightly greater than one. This is in agreement with our expectations.

J. Wage Rate

From the high value of R^2, we know the real wage rate is closely related to the average product of labor, $\frac{Y}{L}$.

K. Government Revenues

The elasticity with respect to the tax base is low. For equations of taxes and other government revenues, we do not have any other study to compare our results with.

Now that we have obtained a set of theoretically valid equations, we will go ahead to simulate the model in the next chapter.

NOTES

[1] The nine principal components are as follows:

Year	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
1957	-305.89	- 62.815	27.391	- 3.9059	- 6.5538	7.9229	-2.9199	.40560	4.0705
1958	-289.64	- 55.970	15.732	- 1.5077	11.604	.81967	7.6432	-5.2128	-1.1670
1959	-267.41	- 51.345	1.0021	1.8410	1.6350	- 3.7477	-5.0854	.41178	3.1602
1960	-245.51	- 39.073	- 3.4318	.90398	.0643	- 2.9610	6.9731	9.9780	-4.3954
1961	-217.94	- 24.621	-11.720	- 7.7573	- 2.2380	- .12945	-7.0567	1.2062	-5.7027
1962	-186.80	- 5.7665	-12.085	3.4896	4.3251	- 9.4722	-5.6445	-7.1689	- .26241
1963	-154.03	13.190	-13.238	8.2318	- 5.8975	- 4.2645	1.5686	.61373	-1.7372
1964	-128.14	24.661	-11.526	10.605	- 8.9324	2.5822	-1.1988	2.3435	6.7548
1965	- 93.796	37.327	-13.196	6.8697	- 1.1066	7.6198	4.7927	-2.7325	-2.9950
1966	- 49.426	51.916	-17.970	- 8.1300	2.9246	4.8994	4.3499	-4.6453	2.8325
1967	.28185	67.779	- 5.9608	-13.087	.30468	3.0615	.0099	2.8979	3.2794
1968	53.917	74.195	7.0543	-13.156	2.6620	.10466	-1.0981	2.4557	-2.0886
1969	103.40	67.583	15.887	- 3.5953	.71909	-10.257	- .94985	- .46519	2.0498
1970	150.48	55.022	18.917	6.0594	- 3.9123	- 1.6062	-2.4037	1.0981	-4.7259
1971	198.59	30.882	14.138	8.2430	- .82986	- .99329	3.2781	-1.3476	1.3232
1972	254.22	3.1438	7.7946	7.5139	- 3.0751	1.5857	2.2153	-2.4433	-1.5134
1973	314.48	- 22.812	- 2.4005	5.4667	8.3311	10.624	-8.2101	.27420	-2.9828
1974	384.23	- 55.294	- 9.0149	3.2417	12.387	- 3.0239	.73735	5.8823	4.7978
1975	479.01	-108.00	- 7.3726	-11.327	-12.411	- 2.7644	2.9989	-3.5516	- .69789

[2] The end-of-year capital stock, gross capital formation, and depreciation used for the econometric model by the Directorate-General of Budget, Accounting and Statistics are as follows:

YEAR	END-OF-YEAR CAPITAL STOCK	GROSS DOMESTIC CAPITAL FORMATION	DEPRECIATION
1953	164.109	7.813	2.682
1954	168.656	8.644	2.756
1955	172.172	7.242	2.788
1956	176.465	8.442	2.858
1957	180.372	8.527	3.121
1958	185.668	10.208	3.351
1959	192.111	11.954	3.896
1960	199.338	14.459	4.613
1961	207.536	16.229	5.153
1962	215.750	17.525	5.873
1963	225.552	18.788	6.715
1964	235.482	22.420	7.536
1965	248.900	28.796	7.908
1966	266.921	32.221	8.685
1967	290.211	40.082	10.133
1968	318.656	47.626	11.533
1969	349.676	49.879	13.114
1970	384.779	60.186	15.750
1971	426.447	67.565	18.273
1972	475.985	68.650	21.146
1973	530.721	81.581	22.953
1974	594.933	112.030	21.191
1975	671.031	95.454	23.850

UNIT: BILLIONS OF 1971 N.T. DOLLARS [82].

CHAPTER 4

SIMULATION OF THE MODEL

I. BASE SIMULATION

We begin by performing a historical simulation to evaluate the performance of the model. Historical time series is used for the exogenous variable. Because our system is not linear, we cannot solve it by matrix inversion, and the solution is obtained by the Gauss-Seidel method [31] [33]. The steps are as follows:

(1) Initial values are assigned to the variables of depreciation (D), age-specific fertility rate (F_k), gross domestic capital formation (I), labor force (L), and disposable income (YD). We start the simulation at 1965, since earlier data for L are not available. Using these initial values and the lagged values of C_F, C_N, D, F_k, I, K, M, P, P_k^i, S_k^i, EX, and Y, we solve sequentially the equations of D, Y, WAG, LP_k^f, LP_k^m, M, EX, G_c, G_o, TAX, C_F, C_N, S_k^f, S_k^m, and F_k. This completes the first iteration.

(2) The values thus obtained are then used to solve the system again. The iteration procedure continues until the desired degree of accuracy is obtained--that is, until each variable changes from iteration to iteration by less than, say, 0.001:

$$\frac{X_{it}^{(r)} - X_{it}^{(r-1)}}{X_{it}^{(r-1)}} < .001$$

where X_i = ith variable

r = number of iterations

t = year 1, 2, ...n

(3) We use the values of the variables thus obtained for year t as the first approximation of their unknown values for year t + 1.

(4) For each year, this process is repeated.

This method converges at a fast rate; for each year's solution, it takes only about six iterations.

II. EVALUATION OF THE MODEL

The method used to evaluate a model depends on the purpose for which the model is built. Because our model is designed to simulate the effects of different fertility trends on economic growth, we must attempt to achieve a standard error of simulation that is as small as possible. We have evaluated each single equation in Chapter 3. The whole model is evaluated as follows [73] [23].

A. Root-mean-square Percentage Error

In order to evaluate the validity of the model, we use the root-mean-square (RMS) percentage error to test the "fitness" of the individual variables in the system:

$$\text{RMS percentage error} = \sqrt{\frac{1}{N} \sum_{t=1}^{N} \left(\frac{X_t^s - X_t^a}{X_t^a} \right)^2}$$

where X_t^s = the simulated value for variable X in year t

X_t^a = the actual value for variable X in year t

N = the number of years in the simulation.

Table 4.1 shows the root-mean-square percentage errors for eleven key variables. In general, the RMS percentage error for each variable is small--only about 2.5%. The actual and simulated time series for

TABLE 4.1

ROOT-MEAN-SQUARE PERCENTAGE ERRORS

INITIAL PERIOD: 1965

Gross reproduction rate	(GRR)	2.95%
Food consumption	(C_F)	2.17
Non-food consumption	(C_N)	2.04
Government consumption	(G_c)	2.74
Labor force	(L)	1.51
GDP	(Y)	3.80
GDP per capita	(YP)	3.69
Disposable income	(YD)	3.75
Capital stock	(K)	3.54
Total population	(P)	0.25
Equivalent adult consumers	(P*)	0.19

these variables are shown in Tables 4.2(1) to 4.2(11), and plotted in Figures 4.1(1) to 4.1(11). The results are all reasonable.

For at least two reasons there are some systematic sources of negative errors in the economic variables from 1970 to 1974: (1) we slightly overestimate fertility rates because some fertility reduction may be explained by non-economic variables; and (2) although the data for 1974 and 1975 showed the highest growth rates of gross capital formation and almost no decline in the growth rates of the labor force and employment, the growth rates of GDP reached the lowest levels during this period. For 1974 and 1975, we cannot use the traditional method because the increase in capital stock in these two years was largely due to government investment in ten major construction projects that were financed by foreign borrowing and that could not be productive for at least three years.

The model is expected to reflect long-run trends accurately, although it may not be able to catch the short-run variations.

B. Sensitivity Test

If the model is "good," the choice of the initial period for simulation should not matter much. To test this property, we begin the simulation in 1970 instead of 1965. The RMS percentage errors are compared in Table 4.3. The internal relationships in the simulation beginning in 1970 are similar to those of the simulation beginning in 1965.

C. *Ex post* Forecast Error

We simulate the model forward in time beyond the estimation period, and compare the results with recent data. The *ex post* RMS forecast error is a very important criterion in testing the validity of a model. Tables 4.4 and 4.5 present the *ex post* forecast results for 1976 and 1977. The errors are all as small as those of historical simulation.

TABLE 4.2

RESULTS OF HISTORICAL SIMULATION

(1) GROSS DOMESTIC PRODUCT

Year	Actual	Simulated	Error	Percent Error
1965	150.7	155.605	4.909	3.26
1966	162.3	166.231	3.883	2.39
1967	179.0	179.401	0.398	0.22
1968	195.1	195.932	0.826	0.42
1969	211.6	213.733	2.145	1.01
1970	234.6	232.751	-1.822	-0.78
1971	261.6	253.866	-7.692	-2.94
1972	292.6	275.794	-16.831	-5.75
1973	327.7	298.909	-28.789	-8.79
1974	329.7	325.245	-4.452	-1.35
1975	339.9	354.990	15.127	4.45

(2) GDP PER CAPITA

Year	Actual	Simulated	Error	Percent Error
1965	11.7	12.007	0.330	2.83
1966	12.3	12.506	0.240	1.96
1967	13.2	13.193	-0.018	-0.13
1968	14.1	14.096	0.036	0.25
1969	14.9	15.016	0.130	0.87
1970	16.1	15.962	-0.167	-1.04
1971	17.6	17.048	-0.533	-3.03
1972	19.3	18.176	-1.089	-5.65
1973	21.2	19.348	-1.839	-8.68
1974	20.9	20.641	-0.294	-1.40
1975	21.2	22.082	0.895	4.23

(3) LABOR FORCE

Year	Actual	Simulated	Error	Percent Error
1965	4.4	4.314	-0.042	-0.97
1966	4.3	4.461	0.119	2.73
1967	4.6	4.627	0.015	0.32
1968	4.8	4.800	-0.048	-0.98
1969	5.0	4.967	-0.058	-1.16
1970	5.2	5.137	-0.013	-0.25
1971	5.3	5.324	-0.008	-0.15
1972	5.5	5.513	-0.017	-0.31
1973	5.9	5.710	-0.176	-2.99
1974	6.0	5.923	-0.124	-2.06
1975	6.1	6.162	0.052	0.85

TABLE 4.2 (Cont.) RESULTS OF HISTORICAL SIMULATION

(4) DISPOSABLE INCOME

Year	Actual	Simulated	Error	Percent Error
1965	111.0	112.005	0.989	0.89
1966	119.6	118.526	-1.055	-0.88
1967	130.1	127.006	-3.076	-2.36
1968	135.9	137.766	1.903	1.40
1969	142.7	149.223	6.534	4.58
1970	161.4	161.561	0.120	0.07
1971	181.1	175.293	-5.811	-3.21
1972	198.7	189.631	-9.053	-4.56
1973	225.7	205.002	-20.688	-9.17
1974	220.5	222.306	1.845	0.84
1975	233.4	240.204	6.831	2.93

(5) GROSS REPRODUCTION RATE

Year	Actual	Simulated	Error	Percent Error
1965	2442.5	2397.101	-45.399	-1.86
1966	2352.5	2350.658	-1.842	-0.08
1967	2235.0	2280.329	45.329	2.03
1968	2190.0	2188.771	-1.229	-0.06
1969	2090.0	2102.835	12.835	0.61
1970	2007.5	2013.339	5.839	0.29
1971	1892.5	1909.328	16.828	0.89
1972	1700.0	1799.736	99.736	5.87
1973	1627.5	1681.063	53.563	3.29
1974	1465.0	1551.494	86.494	5.90
1975	1382.5	1419.267	36.767	2.66

(6) FOOD CONSUMPTION

Year	Actual	Simulated	Error	Percent Error
1965	47.0	45.706	-1.267	-2.70
1966	46.6	47.675	1.094	2.35
1967	49.8	50.034	0.191	0.38
1968	52.0	52.820	0.785	1.51
1969	55.2	55.883	0.686	1.24
1970	60.3	59.173	-1.170	-1.94
1971	62.6	62.671	0.118	0.19
1972	67.0	66.286	-0.727	-1.09
1973	73.6	70.067	-3.524	-4.79
1974	76.0	74.195	-1.761	-2.32
1975	77.5	78.557	1.037	1.34

TABLE 4.2 (Cont.) RESULTS OF HISTORICAL SIMULATION

(7) NON-FOOD CONSUMPTION

Year	Actual	Simulated	Error	Percent Error
1965	43.5	43.114	-0.373	-0.86
1966	47.3	47.790	0.529	1.12
1967	52.8	53.017	0.189	0.36
1968	59.1	58.840	-0.232	-0.39
1969	64.8	65.101	0.345	0.53
1970	69.6	71.723	2.107	3.03
1971	78.5	78.512	-0.031	-0.04
1972	87.8	85.330	-2.471	-2.81
1973	97.3	92.340	-4.967	-5.10
1974	99.6	99.948	0.384	0.39
1975	107.7	107.973	0.275	0.26

(8) GOVERNMENT CONSUMPTION

Year	Actual	Simulated	Error	Percent Error
1965	35.1	34.721	-0.383	-1.09
1966	36.5	37.525	1.038	2.85
1967	39.4	39.822	0.452	1.15
1968	42.0	41.793	-0.215	-0.51
1969	44.3	44.026	-0.295	-0.67
1970	45.5	46.311	0.819	1.80
1971	46.4	48.009	1.598	3.44
1972	48.5	49.339	0.871	1.80
1973	49.1	50.499	1.429	2.91
1974	49.2	51.754	2.516	5.11
1975	55.2	52.852	-2.363	-4.28

(9) CAPITAL STOCK

Year	Actual	Simulated	Error	Percent Error
1965	280.8	289.994	9.219	3.28
1966	304.3	316.405	12.094	3.97
1967	334.3	346.322	12.062	3.61
1968	370.4	382.100	11.747	3.17
1969	407.1	417.646	10.529	2.59
1970	451.6	456.207	4.654	1.03
1971	500.8	494.098	-6.747	-1.35
1972	548.4	526.867	-21.483	-3.92
1973	607.0	570.112	-36.866	-6.07
1974	697.8	663.966	-33.850	-4.85
1975	769.4	756.279	-13.122	-1.71

TABLE 4.2 (Cont.) RESULTS OF HISTORICAL SIMULATION

(10) TOTAL POPULATION

Year	Actual	Simulated	Error	Percent Error
1965	12.9	12.959	0.054	0.42
1966	13.2	13.293	0.057	0.43
1967	13.6	13.598	0.048	0.36
1968	13.9	13.899	0.023	0.17
1969	14.2	14.233	0.020	0.14
1970	14.5	14.581	0.039	0.26
1971	14.9	14.891	0.014	0.09
1972	15.2	15.173	-0.016	-0.10
1973	15.5	15.449	-0.018	-0.12
1974	15.7	15.757	0.008	0.05
1975	16.0	16.076	0.035	0.22

(11) EQUIVALENT ADULT CONSUMERS

Year	Actual	Simulated	Error	Percent Error
1965	9.3	9.352	0.020	0.21
1966	9.6	9.633	0.024	0.25
1967	9.9	9.905	0.028	0.28
1968	10.2	10.177	0.022	0.22
1969	10.5	10.467	0.017	0.16
1970	10.7	10.766	0.023	0.22
1971	11.0	11.043	0.002	0.02
1972	11.3	11.305	-0.018	-0.16
1973	11.6	11.564	-0.018	-0.16
1974	11.8	11.844	-0.001	-0.01
1975	12.1	12.140	0.028	0.23

Unit: (1) Total population and labor force: Millions of persons; (2) Equivalent adult consumers: Millions; (3) Gross reproduction rate: Per 1,000 women; (4) GDP per capita: Thousands of 1971 N.T. dollars; and (5) Other economic variables: Billions of 1971 N.T. dollars.

FIGURE 4.1(1)

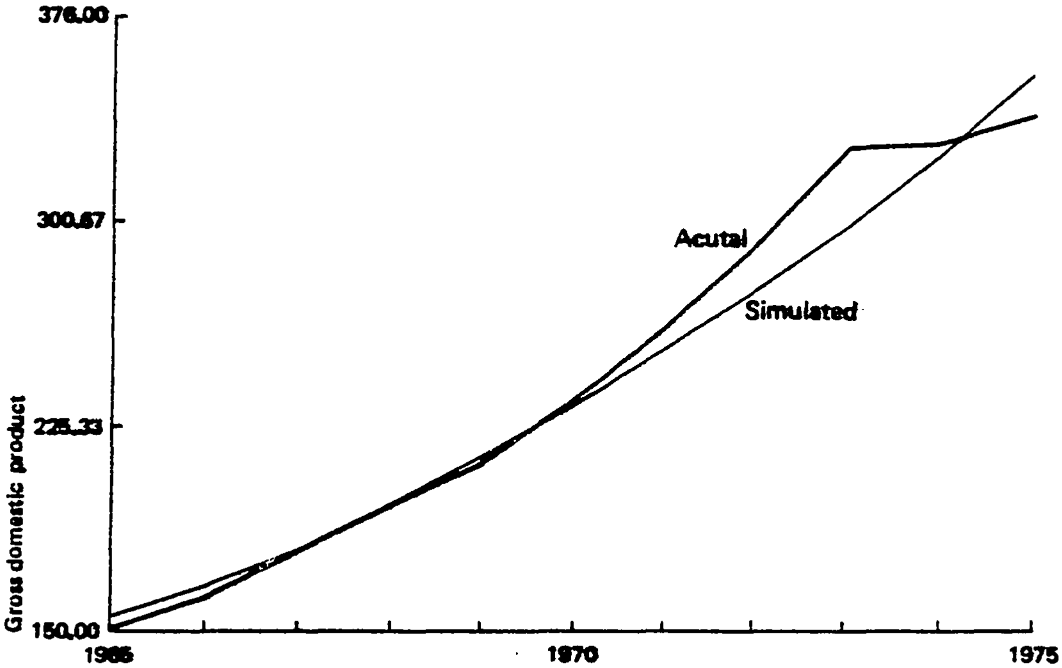

376.00
300.67
225.33
150.00
Gross domestic product
1965
1970
1975
Acutal
Simulated

FIGURE 4.1(2)

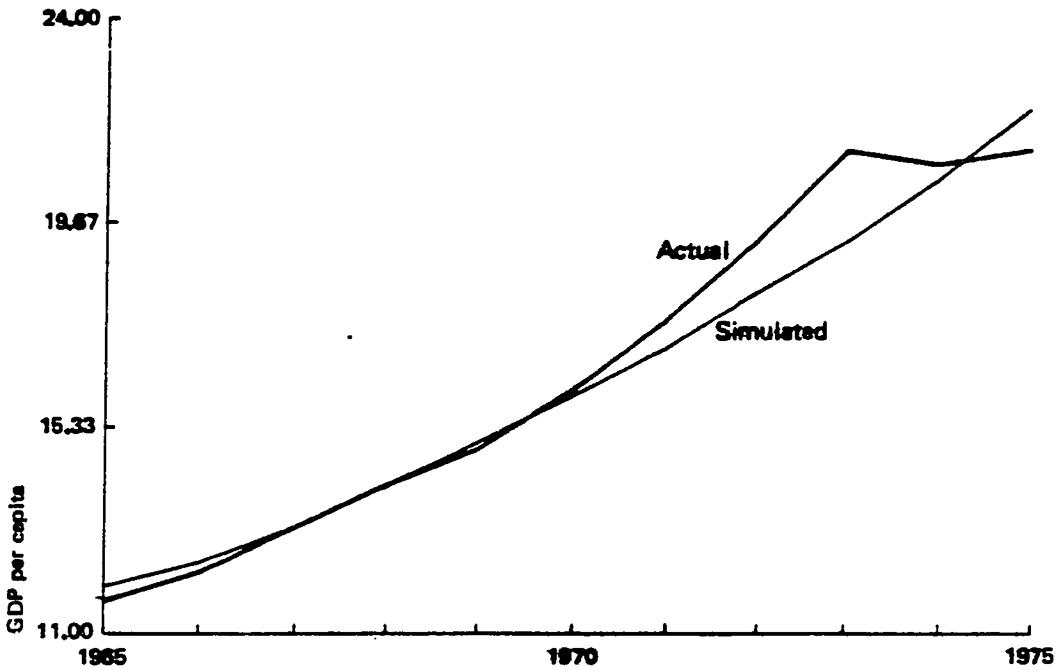

24.00
19.67
15.33
11.00
GDP per capita
1965
1970
1975
Actual
Simulated

FIGURE 4.1(3)

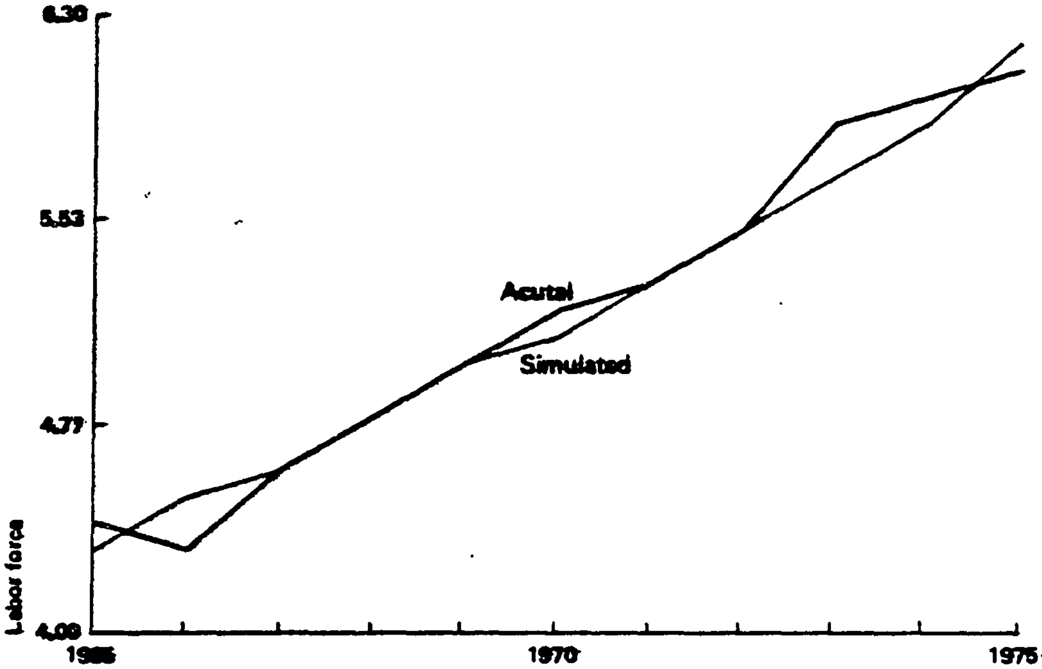


FIGURE 4.1(4)

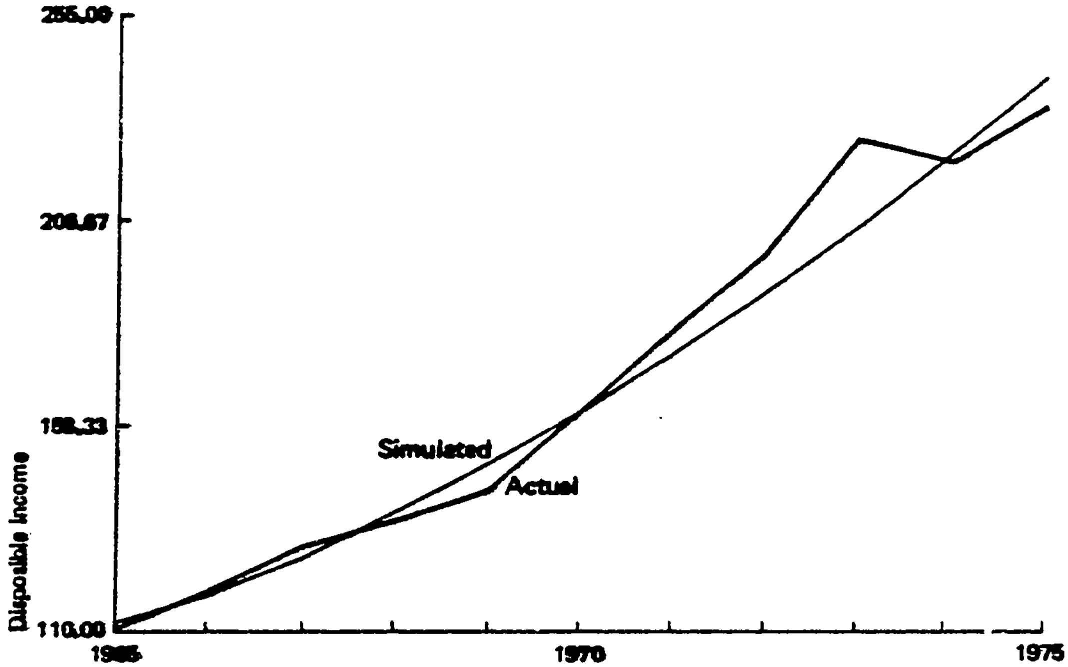

255.00
206.67
158.33
110.00
Disposible Income
Simulated
Actual
1965
1970
1975

FIGURE 4.1(5)

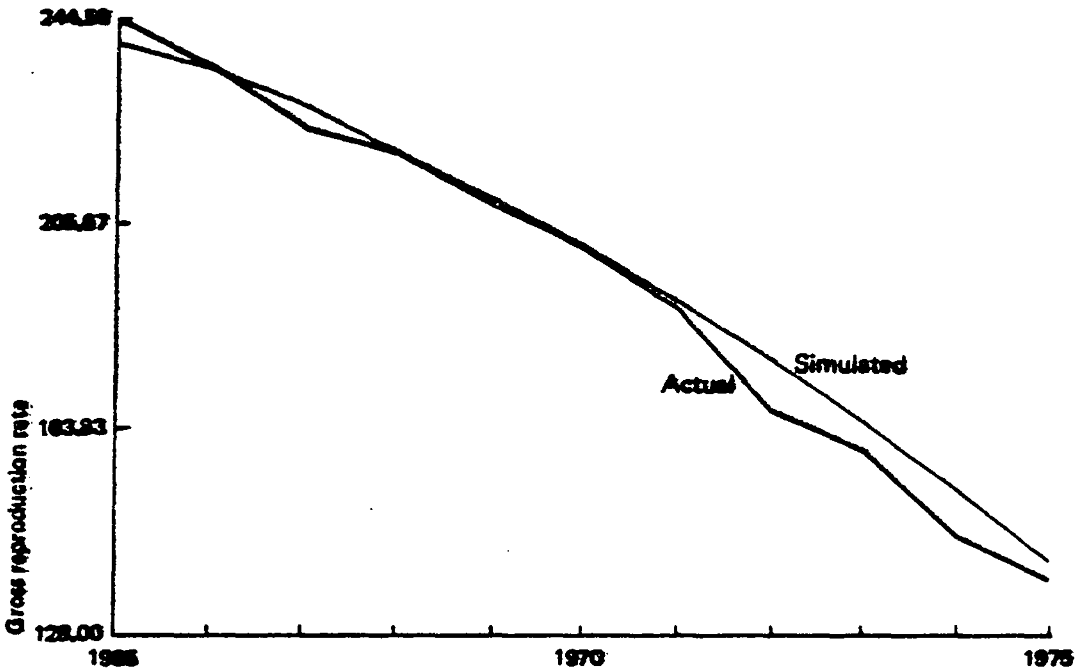


FIGURE 4.1(6)

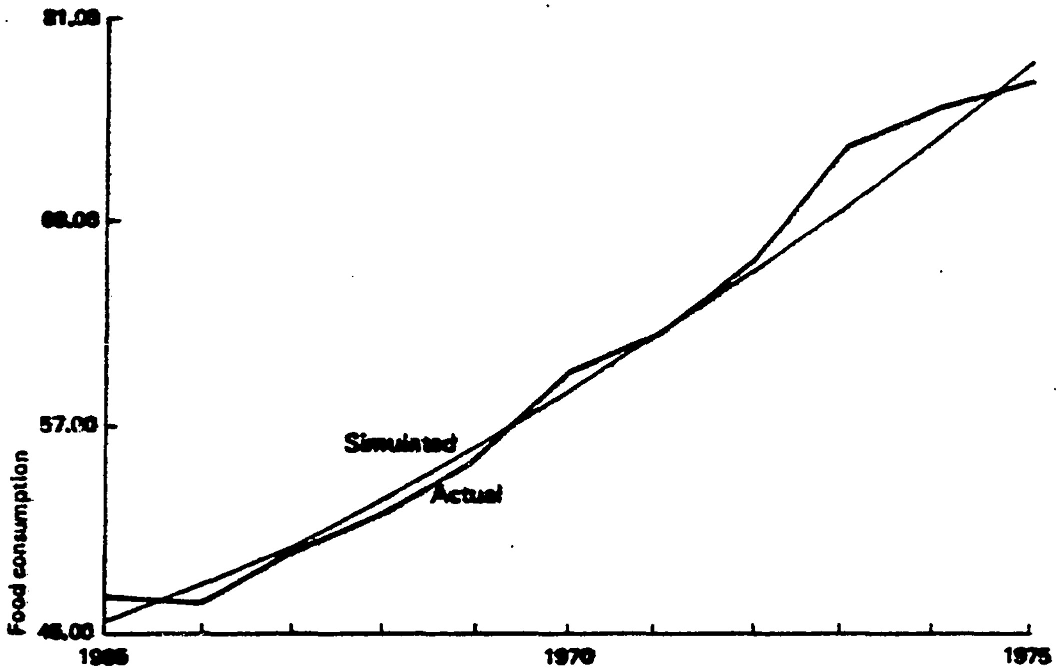


FIGURE 4.1(7)

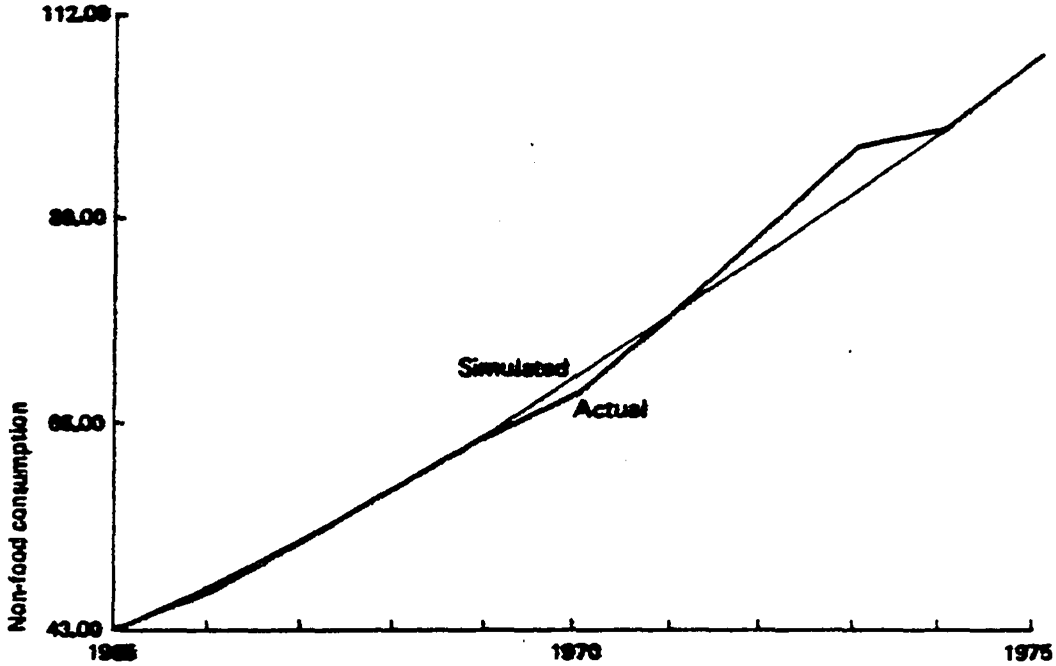

Non-food consumption
112.00
43.00
Simulated
Actual
1970
1975

FIGURE 4.1(8)

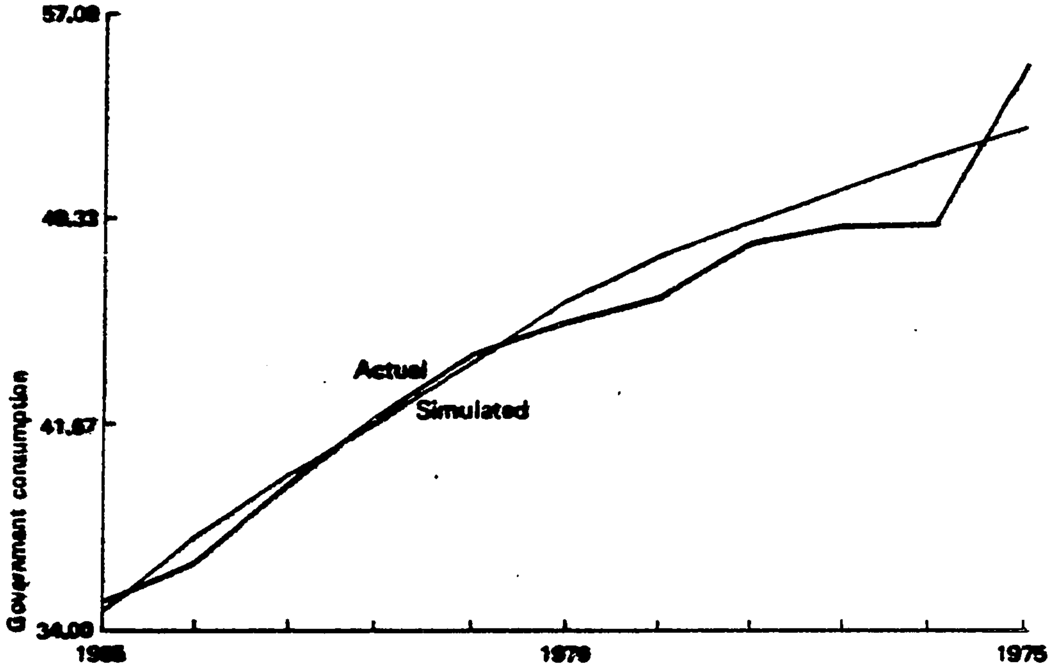


FIGURE 4.1(9)

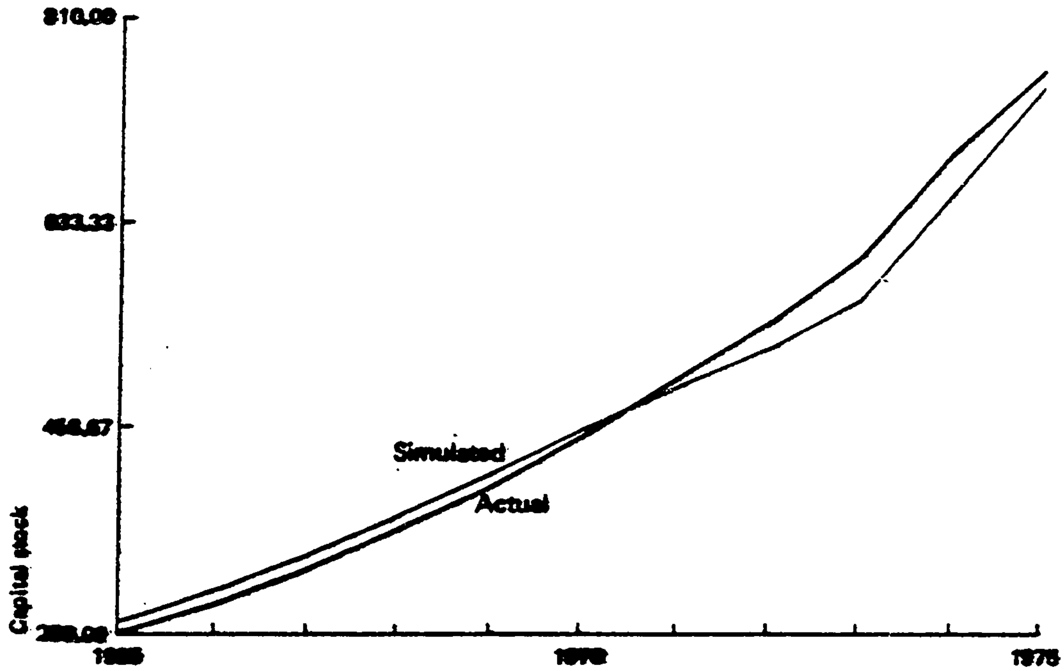


FIGURE 4.1(10).

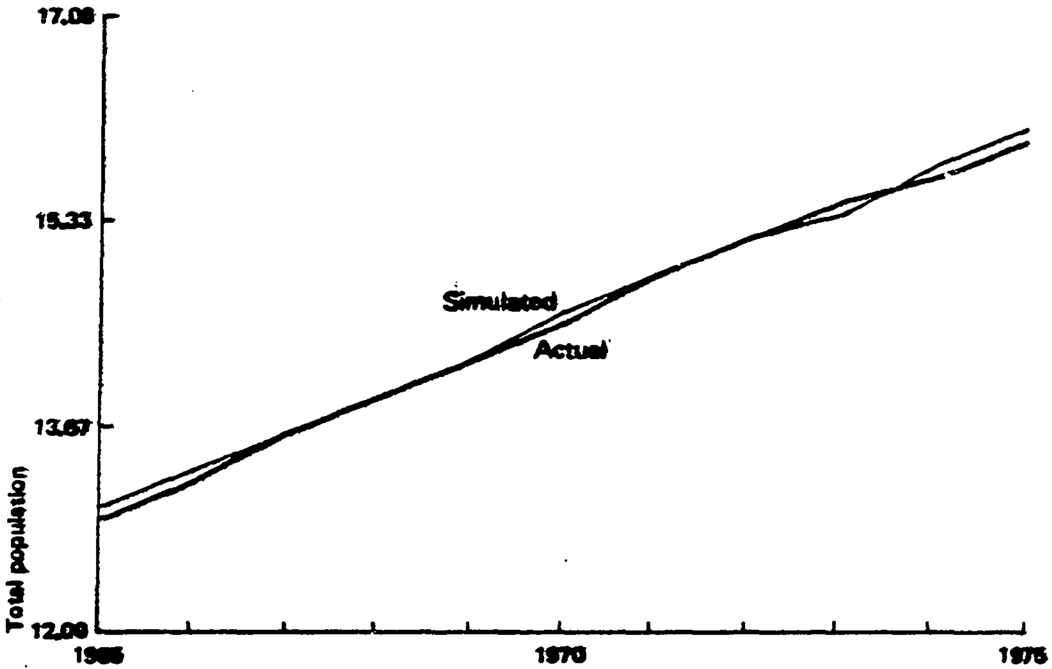

17.08
15.33
13.67
12.00
Total population
Simulated
Actual
1965
1970
1975

FIGURE 4.1(11)

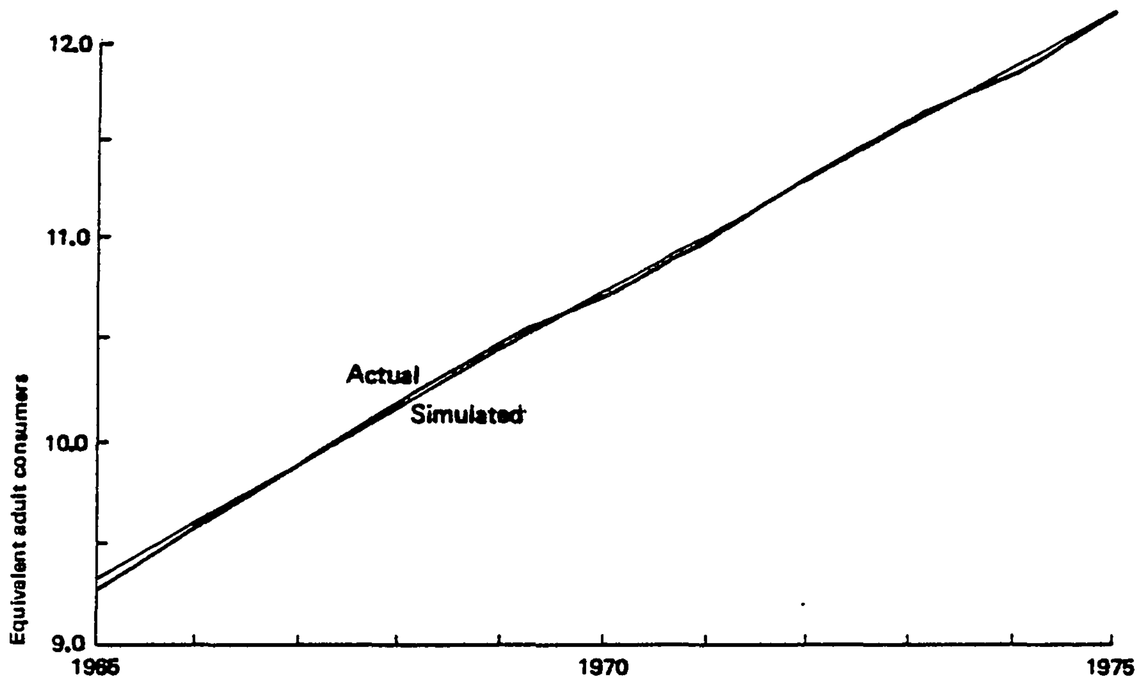

12.0
11.0
10.0
9.0
Equivalent adult consumers
Actual
Simulated
1965
1970
1975

TABLE 4.3

ROOT-MEAN-SQUARE PERCENTAGE ERRORS

INITIAL PERIOD: 1970

Gross reproduction rate	(GRR)	6.61%
Food consumption	(C_F)	3.20
Non-food consumption	(C_N)	3.01
Government consumption	(G_c)	4.48
Labor force	(L)	1.67
GDP	(Y)	5.73
GDP per capita	(YP)	6.23
Disposable income	(YD)	5.28
Capital stock	(K)	7.30
Total population	(P)	0.30
Equivalent adult consumers	(P*)	0.20

TABLE 4.4

<u>EX POST</u> FORECAST RESULTS FOR 1976

VARIABLE	ACTUAL	SIMULATED	ERROR	PERCENTAGE ERROR
Food consumption	81.3	83.6	2.3	2.82
Non-food consumption	115.3	116.7	1.4	1.21
Government expenditures	56.8	55.8	-1.0	-1.76
Gross domestic product	380.2	392.1	11.9	3.13
Gross domestic product per capita	23.0	24.0	1.0	4.35

TABLE 4.5

EX POST FORECAST RESULTS FOR 1977

VARIABLE	ACTUAL	SIMULATED	ERROR	PERCENTAGE ERROR
Food consumption	84.3	89.6	5.3	6.29%
Non-food consumption	124.8	126.8	2.0	1.16
Government expenditures	63.5	58.8	-4.7	-7.40
Gross domestic product	410.1	439.1	29.0	7.07
Gross domestic product per capita	24.4	26.1	1.7	6.85

D. Other Tests

It is difficult to determine whether a certain percentage error is large or small because we have no criterion. However, we can compare the percentage errors from our model with those obtained when using other forecast methods. For example, we can use such simple forecast methods as estimating the values of the variables in 1976 on the basis of the values in 1975, or estimating the values of the variables in 1976 by assuming that the growth rates in 1976 were the same as in 1975. From Tables 4.6 to 4.8, it is apparent that the percentage errors from our model are much smaller than those obtained when using either of these two estimation methods.

III. BASE SIMULATION OF 100 YEARS OF DEMOGRAPHIC AND ECONOMIC GROWTH

After testing the performance of the model, we continue the simulation beyond 1975 and through 2075. We assume that the exogenous variable G_I grows at its historical rate of growth. Table 4.9 reports the simulation of demographic and economic growth for these 100 years. Under the

TABLE 4.6

PERCENTAGE ERRORS WITH THE ASSUMPTION OF $\hat{X}_{1976} = X_{1975}$

VARIABLE	$\hat{X}_{1976} = X_{1975}$	ACTUAL VALUE	ERROR	PERCENTAGE ERROR
Food consumption	77.5	81.3	-3.8	-4.67%
Non-food consumption	107.7	115.3	-7.6	-6.59
Government consumption	55.2	56.8	-1.6	-2.82
Gross domestic product	339.9	380.2	-40.3	-10.60
GDP per capita	21.2	23.0	-1.8	-7.83

TABLE 4.7

PERCENTAGE ERRORS WITH THE ASSUMPTION OF THE SAME GROWTH RATES IN 1976 AND 1975

VARIABLE	$\hat{X}_{1976}$	ACTUAL VALUE	ERROR	PERCENTAGE ERROR
Food consumption	79.1	81.3	-2.2	-2.72%
Non-food consumption	116.5	115.3	1.2	1.48
Government consumption	61.9	56.8	5.1	8.24
Gross domestic product	350.3	380.2	-29.9	-7.86
GDP per capita	21.4	23.0	-1.6	-6.96

TABLE 4.8

COMPARISON OF PERCENTAGE ERRORS

VARIABLE	$\hat{X}_{1976}$ FROM THE MODEL	ASSUME $\hat{X}_{1976} = X_{1975}$	ASSUME THE SAME GROWTH RATES IN 1976 AND 1975
Food consumption	2.83%	-4.67%	-2.71%
Non-food consumption	1.21	-6.59	1.48
Government expenditures	-1.76	-2.82	8.24
Gross domestic product	3.13	-10.60	-7.86
GDP per capita	4.35	-7.83	-6.96

TABLE 4.9

SIMULATION OF 100 YEARS OF
DEMOGRAPHIC AND ECONOMIC GROWTH

YEAR	LABOR FORCE	GROSS DOMESTIC PRODUCT	GDP PER CAPITA	DISPOSABLE INCOME
1965	4.3	155.6	12.0	112.0
1970	5.1	232.8	16.0	161.6
1975	6.2	355.0	22.1	240.2
1980	7.5	617.8	35.8	406.4
1985	8.9	1136.8	61.1	727.7
1990	10.5	2135.0	106.1	1332.9
1995	11.5	3754.5	173.3	2276.7
2000	12.4	6189.6	268.5	3644.4
2005	13.4	9728.3	401.1	5569.4
2010	14.3	14546.1	572.8	8085.5
2015	14.8	20444.1	770.5	10971.7
2020	14.8	27101.5	981.7	13951.5
2025	14.7	34353.9	1205.5	16893.6
2030	14.6	42357.2	1455.3	19898.0
2035	14.6	51325.2	1740.3	23090.7
2040	14.9	61709.7	2073.6	26737.6
2045	15.1	72984.0	2433.3	30403.7
2050	15.2	84482.7	2796.8	33628.7
2055	15.2	96313.5	3165.7	36535.3
2060	15.2	108888.7	3559.1	39431.2
2065	15.3	122506.1	3987.0	42500.8
2070	15.5	136869.6	4436.5	45498.8
2075	15.6	151361.0	4884.8	48007.1

TABLE 4.9 (Cont.) SIMULATION OF 100 YEARS OF DEMOGRAPHIC AND ECONOMIC GROWTH

YEAR	GROSS REPRODUCTION RATE	FOOD CONSUMPTION	NON-FOOD CONSUMPTION	GOVERNMENT CONSUMPTION
1965	2397.1	45.7	43.1	34.7
1970	2013.3	59.2	71.7	46.3
1975	1419.3	78.6	108.0	52.9
1980	1048.4	112.7	163.6	70.0
1985	1048.4	175.1	257.6	101.1
1990	1048.4	290.1	423.2	158.7
1995	1048.4	470.7	677.5	250.5
2000	1048.4	731.1	1040.2	386.6
2005	1048.4	1097.1	1545.0	582.9
2010	1048.4	1579.3	2204.2	849.2
2015	1048.4	2137.9	2962.2	1174.7
2020	1048.4	2720.9	3748.8	1541.6
2025	1048.4	3297.4	4525.2	1940.9
2030	1048.4	3883.8	5314.9	2380.7
2035	1048.4	4502.6	6149.1	2873.0
2040	1048.4	5204.9	7097.3	3442.7
2045	1048.4	5921.6	8059.0	4061.1
2050	1048.4	6559.4	8910.6	4691.8
2055	1048.4	7130.5	9675.1	5340.6
2060	1048.4	7692.7	10431.1	6030.2
2065	1048.4	8288.0	11232.0	6776.8
2070	1048.4	8879.0	12022.6	7564.3
2075	1048.4	9382.2	12691.4	8358.9

TABLE 4.9 (Cont.) SIMULATION OF 100 YEARS OF DEMOGRAPHIC AND ECONOMIC GROWTH

YEAR	CAPITAL STOCK	TOTAL POPULATION	EQUIVALENT ADULT CONSUMERS
1965	290.0	13.0	9.4
1970	456.2	14.6	10.8
1975	756.3	16.1	12.1
1980	1468.8	17.2	13.3
1985	3102.5	18.6	14.5
1990	6603.3	20.1	15.6
1995	13300.8	21.7	16.8
2000	24757.4	23.1	17.9
2005	43085.0	24.3	18.9
2010	70822.7	25.4	19.8
2015	109954.6	26.5	20.6
2020	161539.8	27.6	21.2
2025	225855.9	28.5	21.7
2030	303315.4	29.1	22.1
2035	394766.9	29.5	22.4
2040	502011.8	29.8	22.6
2045	626251.7	30.0	22.8
2050	766693.6	30.2	22.9
2055	922193.7	30.4	23.0
2060	1092656.0	30.6	23.2
2065	1279029.0	30.7	23.3
2070	1481992.0	30.9	23.4
2075	1700542.0	31.0	23.5

UNIT: (1) Total population and labor force: Millions of persons; (2) Equivalent adult consumers: Millions; (3) Gross reproduction rate: Per 1,000 women; (4) GDP per capita: Thousands of 1971 N.T. dollars; and (5) Other economic variables: Billions of 1971 N.T. dollars.

base simulation, even if fertility reached replacement level in 1977, population would still increase by 93%, from 16.1 million in 1975 to 31.0 million in 2075. If the replacement-level fertility continues for about a century, as assumed in our model, the labor force will increase by 152%. Under the simulation for 100 years, gross domestic product and GDP per capita will increase by about 426 and 221 times respectively.

IV. SIMULATION OF THE EFFECTS OF DIFFERENT FERTILITY TRENDS

We also simulate the effects of various fertility trends on economic growth in Taiwan. First, we assume that some kind of effective family planning program could reduce the constant terms of the age-specific fertility equations by 13% from the normal fertility trend. Even when the constant terms are moved, fertility rates are still affected by per capita GDP and female labor force participation rates. Second, we assume that an even more effective family planning program could reduce the constant terms of the fertility equations by 32% from the normal fertility trend.

Under the normal fertility trend assumption (NFT), fertility would reach replacement level in 1977. Under the first assumption, the low fertility trend assumption (LFT), fertility would reach replacement level in 1972, 5 years earlier than in the base simulation. Under the second assumption, the very low fertility trend assumption (VLFT), fertility would be at replacement level in 1967. The result of eleven key variables from these three simulations are reported in Table 4.10.

A. Demographic Finding

Even if fertility in Taiwan reached replacement level (net reproduction rate of about 1,000) immediately, the population would still double before stabilizing because of the young age structure. Because

TABLE 4.10

COMPARISON OF SIMULATION UNDER
DIFFERENT FERTILITY TRENDS

Year	(1) Gross Domestic Product			(2) GDP Per Capita		
	Normal Trend	Low Trend	Very Low Trend	Normal Trend	Low Trend	Very Low Trend
1965	155.6	155.8	156.2	12.0	12.1	12.2
1970	232.8	245.1	254.2	16.0	17.5	18.9
1975	355.0	414.8	458.4	22.1	27.9	32.1
1980	617.8	783.3	894.5	35.8	48.9	58.0
1985	1136.8	1466.1	1656.8	61.1	84.1	98.5
1990	2135.0	2614.7	2833.3	106.1	138.5	156.0
1995	3754.5	4281.2	4496.7	173.3	212.9	234.5
2000	6189.6	6687.5	6844.4	268.5	317.0	342.1
2005	9728.3	10087.6	10153.2	401.1	457.9	486.7
2010	14546.1	14544.6	14305.9	572.8	631.8	656.4
2015	20444.1	19550.2	18710.9	770.5	814.3	825.1
2020	27101.5	24719.7	23084.5	981.7	995.2	988.7
2025	34353.9	30144.7	27669.6	1205.5	1185.9	1163.9
2030	42357.2	36559.0	33723.0	1455.3	1419.9	1405.5
2035	51325.2	44471.3	41015.5	1740.3	1713.7	1699.2
2040	61709.7	53044.5	48374.4	2073.6	2030.7	1992.4
2045	72984.0	61443.2	55336.0	2433.3	2333.6	2257.9
2050	84482.7	69755.6	62318.2	2796.8	2627.5	2523.1
2055	96313.5	78730.2	70266.1	3165.7	2948.3	2831.8
2060	108888.7	88885.4	79361.6	3559.1	3316.3	3189.3
2065	122506.1	99810.7	88826.2	3987.0	3711.4	3557.5
2070	136869.6	110708.9	97938.1	4436.5	4089.5	3902.6
2075	151361.0	121286.7	106772.1	4884.8	4466.9	4231.5

TABLE 4.10 (Cont.) COMPARISON OF SIMULATION UNDER DIFFERENT FERTILITY TRENDS

Year	(3) Labor Force Normal Trend	Low Trend	Very Low Trend	(4) Disposable Income Normal Trend	Low Trend	Very Low Trend
1965	4.3	4.3	4.3	112.0	112.2	112.4
1970	5.1	5.3	5.3	161.6	169.4	174.5
1975	6.2	6.3	6.3	240.2	276.0	301.9
1980	7.5	7.6	7.7	406.4	506.1	572.4
1985	8.9	9.0	9.0	727.7	921.9	1031.0
1990	10.5	10.1	9.7	1332.9	1597.3	1708.0
1995	11.5	10.6	10.1	2276.7	2531.9	2622.7
2000	12.4	11.4	10.8	3644.4	3838.8	3874.4
2005	13.4	12.3	11.7	5569.4	5635.2	5599.6
2010	14.3	13.1	12.3	8085.5	7886.8	7644.0
2015	14.8	13.2	12.2	10971.7	10183.6	9562.4
2020	14.8	12.8	11.7	13951.5	12253.8	11174.9
2025	14.7	12.5	11.4	16893.6	14187.9	12690.5
2030	14.6	12.5	11.7	19898.0	16489.1	14952.3
2035	14.6	13.0	12.2	23090.7	19436.6	17690.0
2040	14.9	13.3	12.4	26737.6	22364.5	20043.4
2045	15.1	13.3	12.3	30403.7	24707.7	21748.5
2050	15.2	13.1	12.1	33628.7	26601.8	23174.7
2055	15.2	13.1	12.2	36535.3	28604.8	24987.7
2060	15.2	13.3	12.4	39431.2	31032.8	27235.7
2065	15.3	13.5	12.6	42500.8	33532.9	29321.6
2070	15.5	13.6	12.6	45498.8	35549.4	30778.0
2075	15.6	13.6	12.6	48007.1	36946.4	31737.8

TABLE 4.10 (Cont.) COMPARISON OF SIMULATION UNDER DIFFERENT FERTILITY TRENDS

Year	(5) Gross Reproduction Rate Normal Trend	Low Trend	Very Low Trend	(6) Food Consumption Normal Trend	Low Trend	Very Low Trend
1965	2397.1	1910.6	1199.0	45.7	45.7	45.6
1970	2013.3	1354.2	1048.4	59.2	59.8	60.1
1975	1419.3	1048.4	1048.4	78.6	83.3	86.6
1980	1048.4	1048.4	1048.4	112.7	128.3	138.9
1985	1048.4	1048.4	1048.4	175.1	207.7	226.3
1990	1048.4	1048.4	1048.4	290.1	337.1	356.9
1995	1048.4	1048.4	1048.4	470.7	516.7	532.8
2000	1048.4	1048.4	1048.4	731.1	765.8	771.0
2005	1048.4	1048.4	1048.4	1097.1	1107.3	1099.0
2010	1048.4	1048.4	1048.4	1579.3	1541.1	1495.6
2015	1048.4	1048.4	1048.4	2137.9	1991.4	1874.9
2020	1048.4	1048.4	1048.4	2720.9	2402.4	2197.8
2025	1048.4	1048.4	1048.4	3297.4	2780.5	2489.3
2030	1048.4	1048.4	1048.4	3883.8	3221.6	2917.6
2035	1048.4	1048.4	1048.4	4502.6	3786.3	3448.3
2040	1048.4	1048.4	1048.4	5204.9	4361.6	3917.9
2045	1048.4	1048.4	1048.4	5921.6	4831.3	4263.6
2050	1048.4	1048.4	1048.4	6559.4	5206.8	4542.7
2055	1048.4	1048.4	1048.4	7130.5	5590.6	4883.7
2060	1048.4	1048.4	1048.4	7692.7	6055.0	5315.0
2065	1048.4	1048.4	1048.4	8288.0	6545.5	5729.6
2070	1048.4	1048.4	1048.4	8879.0	6952.5	6028.3
2075	1048.4	1048.4	1048.4	9382.2	7238.2	6224.6

TABLE 4.10 (Cont.) COMPARISON OF SIMULATION UNDER DIFFERENT FERTILITY TRENDS

Year	(7) Non-Food Consumption			(8) Government Consumption		
	Normal Trend	Low Trend	Very Low Trend	Normal Trend	Low Trend	Very Low Trend
1965	43.1	42.9	42.7	34.7	33.9	32.7
1970	71.7	71.5	70.4	46.3	39.3	32.0
1975	108.0	111.2	113.6	52.9	35.0	24.6
1980	163.6	180.0	191.3	70.0	76.7	81.6
1985	257.6	295.5	317.0	101.1	116.8	126.1
1990	423.2	479.1	501.5	158.7	182.6	193.2
1995	677.5	730.5	747.0	250.5	276.3	286.3
2000	1040.2	1075.8	1076.4	386.6	410.1	416.6
2005	1545.0	1545.2	1526.5	582.9	598.3	599.6
2010	2204.2	2135.7	2064.6	849.2	844.5	829.0
2015	2962.2	2743.3	2574.7	1174.7	1120.8	1072.2
2020	3748.8	3294.8	3006.7	1541.6	1405.7	1313.2
2025	4525.2	3804.2	3401.3	1940.9	1704.2	1565.3
2030	5314.9	4402.1	3984.7	2380.7	2056.4	1897.6
2035	6149.1	5166.8	4700.4	2873.0	2490.5	2297.5
2040	7097.3	5937.3	5325.4	3442.7	2960.7	2701.2
2045	8059.0	6561.5	5783.0	4061.1	3421.4	3083.2
2050	8910.6	7062.6	6157.3	4691.8	3877.5	3466.2
2055	9675.1	7581.4	6621.5	5340.6	4369.7	3902.1
2060	10431.1	8209.6	7204.3	6030.2	4926.5	4400.7
2065	11232.0	8866.8	7757.1	6776.8	5525.5	4919.7
2070	12022.6	9406.4	8150.6	7564.3	6123.0	5419.3
2075	12691.4	9783.4	8409.6	8358.9	6703.1	5903.8

TABLE 4.10 (Cont.) COMPARISON OF SIMULATION UNDER DIFFERENT FERTILITY TRENDS

Year	(9) Capital Stock			(10) Total Population		
	Normal Trend	Low Trend	Very Low Trend	Normal Trend	Low Trend	Very Low Trend
1965	290.0	291.2	293.1	13.0	12.9	12.8
1970	456.2	501.2	555.2	14.6	14.0	13.4
1975	756.3	1007.4	1194.4	16.1	14.9	14.3
1980	1468.8	2081.7	2513.7	17.2	16.0	15.4
1985	3102.5	4426.5	5279.9	18.6	17.4	16.8
1990	6603.3	9014.5	10374.7	20.1	18.9	18.2
1995	13300.8	16885.0	18717.6	21.7	20.1	19.2
2000	24757.4	29399.5	31550.2	23.1	21.1	20.0
2005	43085.0	48427.8	50684.3	24.3	22.0	20.9
2010	70822.7	76117.9	77905.9	25.4	23.0	21.8
2015	109954.6	113395.2	113451.2	26.5	24.0	22.7
2020	161539.8	159944.1	156541.2	27.6	24.8	23.3
2025	225855.9	215186.2	206422.2	28.5	25.4	23.8
2030	303315.4	280136.0	265326.9	29.1	25.7	24.0
2035	394766.9	357350.4	335911.6	29.5	26.0	24.1
2040	502011.8	448071.5	418039.3	29.8	26.1	24.3
2045	626251.7	550961.2	509651.0	30.0	26.3	24.5
2050	766693.6	664162.6	609148.9	30.2	26.5	24.7
2055	922193.7	787542.6	717382.4	30.4	26.7	24.8
2060	1092656.0	922836.1	836596.7	30.6	26.8	24.9
2065	1279029.0	1071349.0	967377.7	30.7	26.9	25.0
2070	1481992.0	1232216.0	1108005.0	30.9	27.0	25.1
2075	1700542.0	1403331.0	1256441.0	31.0	27.2	25.2

TABLE 4.10 (Cont.) COMPARISON OF SIMULATION UNDER DIFFERENT FERTILITY TRENDS

Year	(11) Equivalent Adult Consumers Normal Trend	Low Trend	Very Low Trend
1965	9.4	9.3	9.3
1970	10.8	10.6	10.4
1975	12.1	11.6	11.3
1980	13.3	12.6	12.1
1985	14.5	13.5	13.0
1990	15.6	14.5	14.0
1995	16.8	15.6	14.9
2000	17.9	16.5	15.7
2995	18.9	17.3	16.3
2010	19.8	17.9	16.9
2015	20.6	18.5	17.4
2020	21.2	18.9	17.7
2025	21.7	19.3	18.0
2030	22.1	19.6	18.2
2035	22.4	19.7	18.4
2040	22.6	19.9	18.4
2045	22.8	20.0	18.5
2050	22.9	20.1	18.7
2055	23.0	20.2	18.8
2060	23.2	20.3	18.9
2065	23.3	20.4	18.9
2070	23.4	20.5	19.0
2075	23.5	20.5	19.1

UNIT: (1) Total population and labor force: Millions of persons; (2) Equivalent adult consumers: Millions; (3) Gross reproduction rate: Per 1,000 women; (4) GDP per capita: Thousands of 1971 N.T. dollars; and (5) Other economic variables: Billions of 1971 N.T. dollars.

of declining fertility and increasing survival rate, the proportion of population 65 years and over will gradually increase.

As fertility declines, the immediate effects will be a slower population growth rate, a lower young dependency ratio, and a higher female labor force participation rate. Projections for a century hence, using the three fertility trend assumptions, indicate that the very low fertility trend assumption produces the smallest total population, the smallest labor force, the smallest number of equivalent adult consumers.

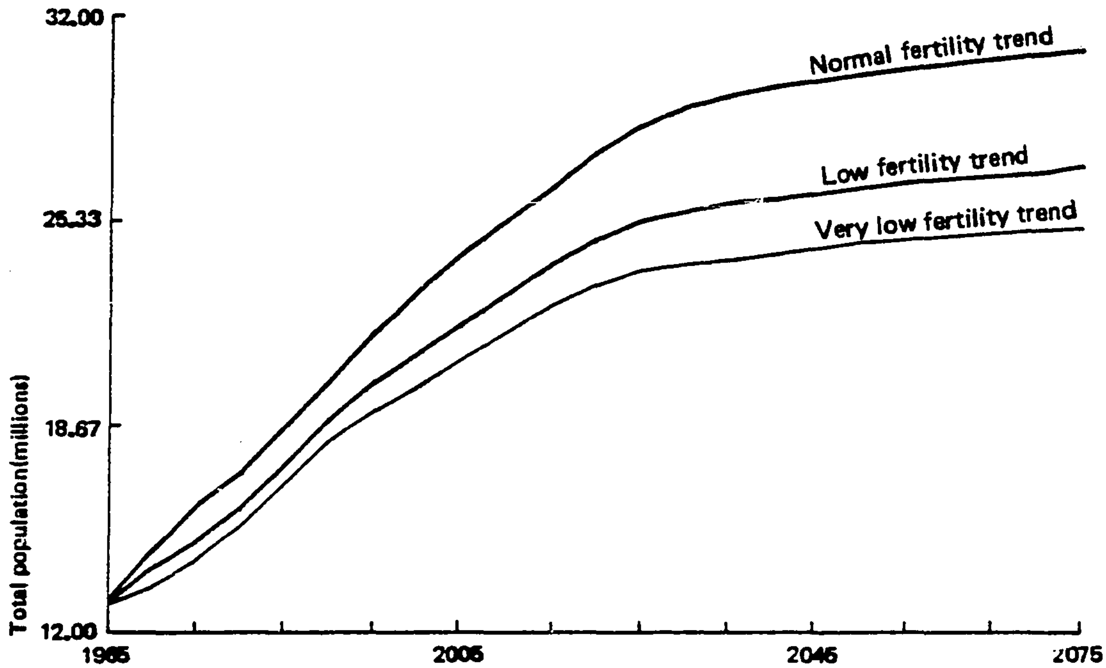
1. Total Population

The population of Taiwan in 1975 was about 16.1 million. The VLFT assumption, under which replacement-level fertility would be reached in 1967, would produce a population of 25.2 million by 2075. The LFT assumption, under which replacement-level fertility would be reached in 1972, would generate a population of 27.2 million by 2075. The NFT assumption, under which replacement-level fertility would be reached around 1977, would produce a population of 31.0 million by 2075. Under these fertility assumptions, population would increase from 1975 to 2075 by 93%, 83%, and 76% respectively, as shown in Table 4.10(10) and Figure 4.2.

2. Labor Force

As shown in Table 4.10(3), the labor force increases under all three fertility assumptions. Because of the increased labor force participation rates resulting, directly and indirectly, from the lower fertility rates, about 20 years after the differences in fertility rates are established the low and very low fertility trend populations have slightly larger labor forces than the NFT population. Afterwards, the NFT population produces a larger labor force. For 2075, the NFT assump-

FIGURE 4.2 COMPARISON OF TOTAL POPULATION UNDER DIFFERENT FERTILITY TRENDS



tion produces a labor force that is about 2.0 million, or 14.7%, greater than that produced by the LFT assumption, and about 3.0 million, or 23.8%, greater than that produced by the VLFT assumption.

3. Equivalent Adult Consumers

Regardless of the fertility assumptions, the number of equivalent adult consumers in Taiwan will increase considerably over the next century, as shown in Table 4.10(11). The number of equivalent adult consumers grows faster under the NFT assumption than under the LFT and VLFT assumptions. For 2075, the NFT assumption produces about 3.0 million, or 14.6%, more equivalent adult consumers than does the LFT assumption, and nearly 4.4 million, or 23.0% more than does the VLFT assumption.

B. Economic Findings

By 2075, under all three fertility trend assumptions, the gross domestic product and GDP per capita will have increased by more than 426 and 221 times respectively, as shown in Table 4.10(1) and (2). These results are based on the coefficients taken from the sample period of rapid economic growth. These coefficients may not be realistic, however, so we also calculate the ratios of GDP's and per capita GDP's under the three fertility trend assumptions; these results, shown in Table 4.11, presumably will be stable. Although the NFT assumption eventually generates slightly larger GDP and per capita GDP than do the LFT and VLFT assumptions, the NFT assumption produces substantially smaller GDP and per capita GDP in the near future, up to 40 to 60 years. When we use a 10% rate of discount and compare the sums of the present values of the annual GDP per capita for the VLFT and NFT populations, the former population shows a 26% higher sum (as shown in Table 4.13). However,

TABLE 4.11

RATIOS OF GDP'S AND PER CAPITA GDP'S
UNDER DIFFERENT FERTILITY TRENDS
(BASE: N.F.T. POPULATION = 100) UNIT: %

YEAR	(1) GROSS DOMESTIC PRODUCT			(2) GDP PER CAPITA		
	NORMAL TREND	LOW TREND	VERY LOW TREND	NORMAL TREND	LOW TREND	VERY LOW TREND
1965	100.0	100.1	100.4	100.0	100.7	101.8
1970	100.0	105.3	109.2	100.0	109.4	118.5
1975	100.0	116.8	129.1	100.0	126.2	145.5
1980	100.0	126.8	144.8	100.0	136.4	161.9
1985	100.0	129.0	145.7	100.0	137.8	161.2
1990	100.0	122.5	132.7	100.0	130.6	147.1
1995	100.0	114.0	119.8	100.0	122.9	135.3
2000	100.0	108.0	110.6	100.0	118.0	127.4
2005	100.0	103.7	104.4	100.0	114.2	121.3
2010	100.0	100.0	98.3	100.0	110.3	114.6
2015	100.0	95.6	91.5	100.0	105.7	107.1
2020	100.0	91.2	85.2	100.0	101.4	100.7
2025	100.0	87.7	80.5	100.0	98.4	96.5
2030	100.0	86.3	79.6	100.0	97.6	96.6
2035	100.0	86.6	79.9	100.0	98.5	97.6
2040	100.0	86.0	78.4	100.0	97.9	96.1
2045	100.0	84.2	75.8	100.0	95.9	92.8
2050	100.0	82.6	73.8	100.0	93.9	90.2
2055	100.0	81.7	73.0	100.0	93.1	89.5
2060	100.0	81.6	72.9	100.0	93.2	89.6
2065	100.0	81.5	72.5	100.0	93.1	89.2
2070	100.0	80.9	71.6	100.0	92.4	88.0
2075	100.0	80.1	70.5	100.0	91.4	86.6

TABLE 4.12

THE SUMS OF THE PRESENT VALUES OF
THE ANNUAL GDP'S UNDER DIFFERENT FERTILITY TRENDS

	RATE OF DISCOUNT	NORMAL FERTILITY TREND	LOW FERTILITY TREND	VERY LOW FERTILITY TREND
	0%	4,938.2	4,154.0	3,758.7
GDP	5%	123.0	114.0	108.9
	10%	12.4	13.1	13.4
	0%	165.8	159.0	154.7
GDP per capita	5%	4.6	4.9	5.0
	10%	.6	.7	.7
	0%	218.2	209.3	203.7
GDP per equivalent adult consumers	5%	6.0	6.3	6.5
	10%	.8	.9	.9

UNIT: (a) GDP: trillions of 1971 N.T. dollars; (b) GDP per capita and GDP per equivalent adult consumers: millions of 1971 N.T. dollars.

TABLE 4.13

RATIOS OF THE PRESENT VALUES OF
GDP'S UNDER DIFFERENT FERTILITY TRENDS
(BASE: N.F.T. POPULATION = 100) UNIT: %

	RATE OF DISCOUNT	NORMAL FERTILITY TREND	LOW FERTILITY TREND	VERY LOW FERTILITY TREND
	0%	100.0	84.12	76.12
GDP	5%	100.0	92.70	88.53
	10%	100.0	105.66	108.32
	0%	100.0	95.86	93.30
GDP per capita	5%	100.0	105.12	107.68
	10%	100.0	116.48	126.44
	0%	100.0	95.90	93.36
GDP per equivalent adult consumers	5%	100.0	105.05	107.57
	10%	100.0	115.75	125.23

these results are based on fixed retirement age. In addition, the sums of the present values are sensitive to the choices of discount rates and the time span considered.

1. Gross Domestic Product

Under all fertility assumptions, gross domestic product increases monotonically although at different rates. In the short run, the lower fertility populations produce larger GDP than the normal fertility population because (1) the lower fertility leads to a higher female labor force participation rate; (2) for the first fifteen years the lower fertility does not affect the size of the population in the working ages of 15 to 64; and (3) the positive effects of larger capital formation, which is derived from reduced consumption as a result of the fertility reduction, dominate the negative effects of the more slowly growing labor force.

However, in the long run, the lower fertility populations produce a smaller GDP than the normal fertility population because (1) the negative effects of a slower growing labor force dominate the positive effects of faster growing capital formation; and (2) the lower fertility populations eventually have higher ratios of equivalent adult consumers to labor force and, consequently, slower growth in capital formation.

With the normal fertility trend assumption as a base for comparison, Table 4.11 and Figures 4.3 and 4.4 present the ratios of gross domestic product and per capita gross domestic product under the lower fertility assumptions. Specifically, comparing the NFT population and the LFT population, we find that the LFT population at first generates a higher GDP; the ratio increases with time until it reaches its peak in 1985, at which point the LFT population produces a GDP 29.0% higher than that of the NFT population. After 2010, the LFT population constantly produces a

FIGURE 4.3 COMPARISON OF GDP UNDER DIFFERENT FERTILITY TRENDS

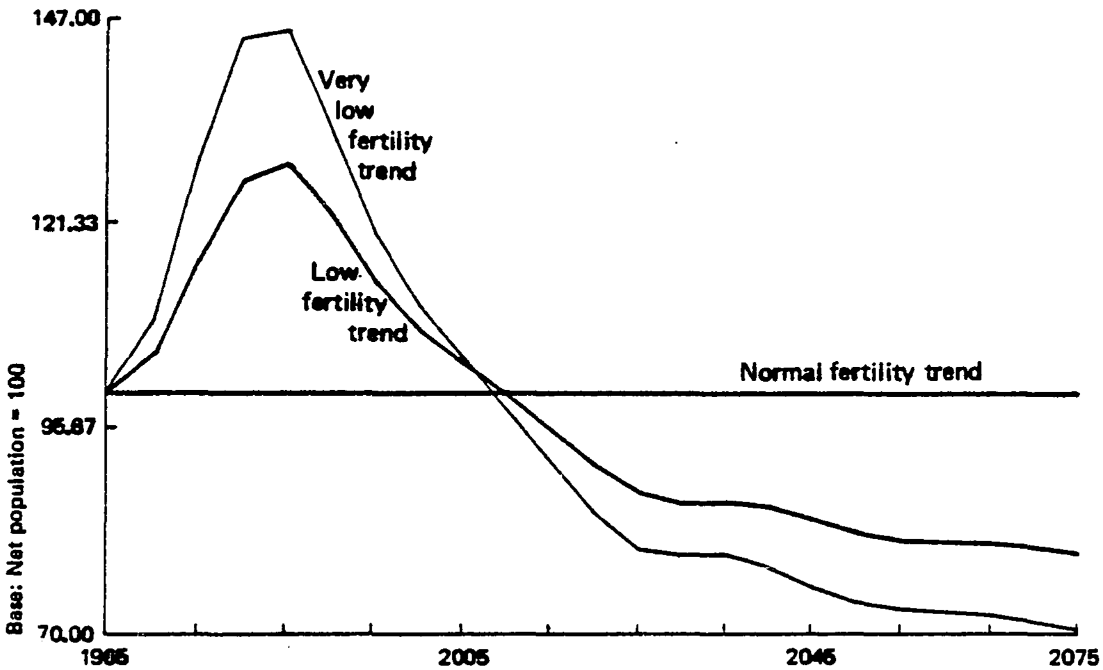
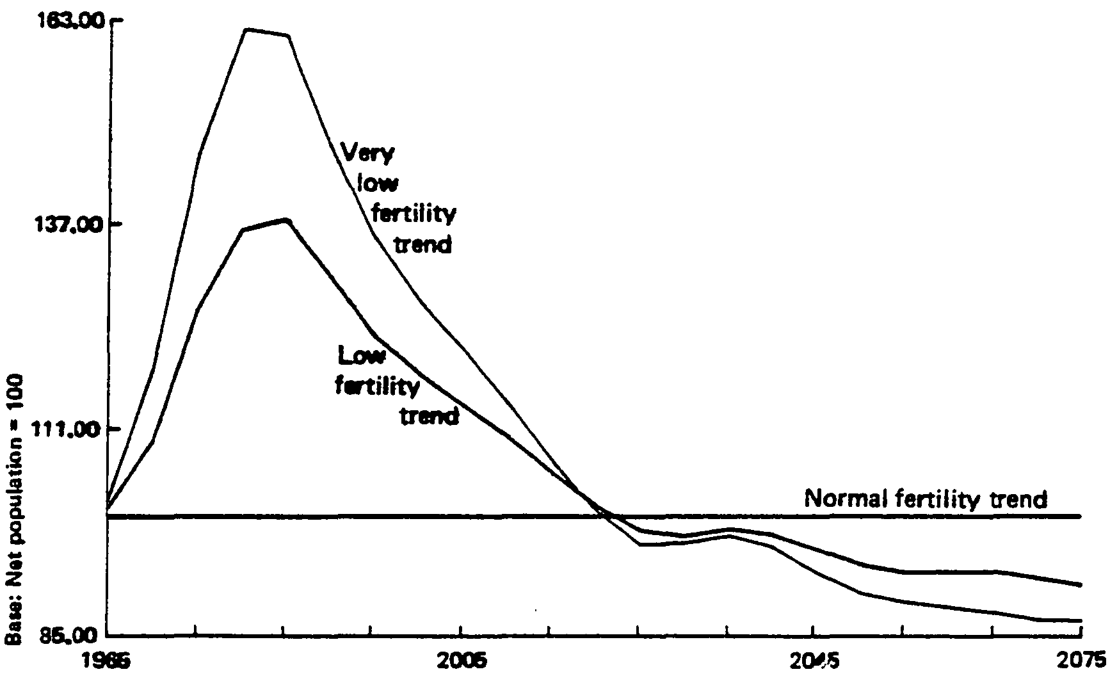


FIGURE 4.4 COMPARISON OF PER CAPITA GDP UNDER DIFFERENT FERTILITY TRENDS



smaller GDP than does the NFT population, and the difference keeps getting larger; by 2075, the LFT population produces only 80.1% of the GDP generated by the NFT population.

Similarly, the VLFT population produces a larger GDP during the initial 45 years than does the normal fertility trend population. Then the situation reverses. In 2075, the GDP produced by the VLFT population is only 70.5% of that produced by the NFT population.

Table 4.12 shows the sums of the present values of the annual GDP's under the three fertility trend assumptions, and Table 4.13 reports the ratios of these values. If no discount rate is used, the NFT population shows a higher sum of the annual GDP than do the LFT and VLFT populations. However, if a 10% rate of discount is used, the LFT and VLFT populations generate 6% and 8% respectively higher sums of the present values of the annual GDP than does the NFT population.

2. GDP Per Capita

Like the GDP, the per capita gross domestic product also increases monotonically under all three fertility assumptions. The two lower fertility trend populations generate larger GDP per capita in the short run and then smaller GDP per capita after about 60 years. The intersection is about 10 years later than in the case of GDP because of the advantages of fewer persons sharing the GDP.

Compared with the NFT population, the LFT population at first produces a higher GDP per capita; the ratio increases with time until it reaches its peak in 1985, at which point the LFT population generates a GDP per capita that is 37.8% higher than that of the NFT population. After 2020, the LFT population generates a smaller GDP per capita than does the NFT population; in 2075, the GDP per capita generated by the LFT population is only 91.4% of that generated by the NFT population.

Correspondingly, the very low fertility trend population at first produces a substantially higher GDP per capita than the NFT population—the ratio is 61.9% more in 1980. The ratios remain higher until 2020. At the end of the simulation in 2075, the very low fertility population produces a GDP per capita that is only 86.6% of that produced by the normal fertility trend population, as shown in Table 4.11 and Figure 4.4.

When we use the production function $\text{Ln } Y = -0.0034 + 0.6910 \text{ Ln } K^* + 0.6619 \text{ Ln } L$, which is the one before we constrain the parameters of K^* and L, we get similar results.

When we use the functional form $\text{Ln } Y = a + b \text{ Ln } K_{-1} + c \text{ Ln } L$ for the sample period 1965-1973, we get the equation $\text{Ln } Y = -0.478068 + 0.926043 \text{ Ln } K_{-1} + 0.233259 \text{ Ln } L$. The coefficient of capital is about four times that of labor. The ex post forecast errors from this equation are too big—more than 10%. However, the conclusion is similar: the low and very low fertility trend assumptions generate substantially larger GDP up to 100 years and larger GDP per capita up to 135 years than the normal fertility trend assumption. The low and very low fertility trend assumptions eventually produce slightly smaller GDP and smaller GDP per capita.

However, these results depend on two not very reasonable assumptions: (1) the retirement age will remain fixed as the opportunity costs of retirement increase resulting from labor shortage and thus wage increase; and (2) no further progress in the output per worker takes place as consumption increases relative to income and the capital stock—this increase should increase demand for capital and labor to produce consumer's goods and give rise to an excess demand for labor with induced changes in productivity.

If no discount rate is used, the LFT and VLFT populations produce smaller sums of the annual GDP per capita than does the NFT population. However, when a 5% rate of discount is used, the LFT and VLFT populations respectively generate 5% and 8% larger sums of present values of the annual GDP per capita than does the NFT population. If a 10% discount rate is used, the LFT and VLFT populations respectively produce 16% and 26% higher sums than does the NFT population. The ratios of the sums of present values are about the same for GDP per capita and GDP per equivalent adult consumers, as shown in Tables 4.12 and 4.13.

Ogawa [70] finds that a high fertility population eventually produces a larger GNP than does a lower fertility population. He also observes that a lower fertility population generates larger GNP per capita than a high fertility population, but the ratio, after reaching its peak, continuously narrows until the end of the simulation--2025. Had he extended the simulation beyond 2025, he might have also found that a lower fertility population eventually produces smaller GNP per capita.

3. Output Per Worker

Table 4.14 shows the output per worker under the three fertility trend assumptions. The LFT and VLFT populations produce a substantially larger output per worker in the near future, up to 2030, and then generate a slightly smaller output per worker. Specifically, the VLFT population gradually generates a larger output per worker, and reaches its peak around 1985 at which point the VLFT population has an output per worker about 44% higher than does the NFT population. After 2030, the VLFT population produces a smaller capital per worker, and hence a smaller output per worker than does the NFT population; in 2075, the

TABLE 4.14

OUTPUT PER WORKER UNDER DIFFERENT FERTILITY TRENDS

YEAR	NORMAL TREND	LOW TREND	VERY LOW TREND
1965	36.1	36.1	36.1
1970	45.3	46.0	47.7
1975	57.6	65.9	72.4
1980	82.9	102.7	116.0
1985	128.3	162.9	185.0
1990	204.2	260.0	293.5
1995	326.2	403.0	444.0
2000	498.9	588.9	634.4
2005	725.1	821.4	866.9
2010	1015.2	1113.8	1161.0
2015	1382.3	1484.3	1532.2
2020	1828.4	1926.4	1966.9
2025	2342.9	2415.5	2433.9
2030	2907.9	2916.9	2884.0
2035	3511.7	3427.5	3356.8
2040	4142.8	3993.4	3903.4
2045	4824.7	4631.2	4516.5
2050	5569.4	5313.6	5156.3
2055	6356.7	6001.7	5781.6
2060	7164.9	6683.6	6400.7
2065	7985.5	7385.5	7053.7
2070	8831.5	8133.0	7758.0
2075	9717.1	8921.3	8492.8

UNIT: Thousands of 1971 N.T. dollars

VLFT population generates only 87% of the output per worker produced by the NFT population.

V. ESTIMATE OF THE VALUE OF AVERTED BIRTHS

The main economic benefits of an averted birth in terms of market goods obtained by the participating family include (1) consumption expenditures saved by the averted birth and (2) increased output resulting from higher female labor force participation. On the other hand, the main economic costs (foregone economic benefits) of the averted birth include (1) the output that would otherwise have been produced by the unborn child and (2) the economic costs of preventing the birth through contraception. However, if the averted child after maturity had left the parents, the parents would not have foregone the economic benefits that would otherwise have been produced by the unborn child. The net economic value is the difference between the economic benefits and costs.

To estimate the economic benefits and costs of fertility reduction obtainable by the participating families, we begin by reducing the constant terms of the age-specific fertility equations in 1965 by multiplying them by 0.7. The number of births would be about 171,000 smaller than otherwise in that year. Then the following procedures are followed to estimate the value of births averted if the children had stayed with their parents after maturity:

(1) Assess the private consumption saved by averting the births through the projected lifetimes of the averted children, male until age 65 and female until age 70, the life expectancies at birth in 1965 in Taiwan.

(2) Estimate the increase of output resulting from increased female labor force participation rates as the result of the faster fertility reduction.

(3) Estimate the increase in output that would otherwise have been produced by the prevented children.

(4) Assume that the families need not pay the costs of contraception to prevent the births but that the costs are born by the government through the family planning program. Even though we do not know exactly how effective the family planning program is in Taiwan, to get a rough estimate of the contraceptive costs of preventing a birth we divide the number of births which the family planning program [104] claims to have averted into the total cost of the program. The result is about N.T.$39.1 (at 1971 prices) per averted birth. The costs of preventing a birth are, therefore, too small to have a significant effect on the total benefits.

(5) Calculate the 1965 present value of the benefits and costs estimated in the preceding four items at a discount rate of 20%. Then, compare the benefits of the averted births (the first two items) with the costs of the averted births (the third item) to get the net benefits. The benefits are around $13.62 billion--roughly $11.65 billion from consumption saved, and nearly $1.96 billion from increased female labor force participation. The cost of foregone output is approximately $10.13 billion. Thus, the net benefits are about $3.49 billion.

(6) Divide the net benefits by the number of births averted, in order to obtain the net benefit per averted birth for the family reducing its fertility. This is about $20,443 (1971 N.T. dollars).

If the averted children would have left their parents after maturity, the parents would not have obtained the potential output that would otherwise have been produced by those children. Therefore, if the averted children had left their parents after maturity, the total value of 171,000 births averted would be $9.20 billion, of which $7.23 billion is from the

15 years' consumption expenditures saved by averting the births, and $1.97 billion is from the increased output resulting from higher female labor force participation. The value per averted birth is then $53,889.

To estimate the distribution of the economic benefits between the participating families and the society at large, we used the method pioneered by Suits and Mason [67].

The gross domestic product per equivalent adult consumer in year t under normal and low fertility trends is (GDP_t^N / P_t^N) and (GDP_t^L / P_t^L), respectively. In year t, the total GDP required to provide the smaller number of equivalent adult consumers (P_t^L) with GDP_t^N / P_t^N (the amount of GDP per equivalent adult consumers under the normal fertility trend) is $(GDP_t^N / P_t^N) \times P_t^L$. The net value $V_t = GDP_t^L - (GDP_t^N / P_t^N) \times P_t^L$ is the gain in year t from fertility reduction if V_t is positive. However, V_t may be negative; then there is loss.

The total economic benefits are the sum of the yearly economic benefits discounted to 1965 by 20%. Finally, the economic benefit per birth averted is obtained by dividing the number of averted births into the total economic benefits. The total economic benefits are about $130.60 billion (1971 N.T. dollars) and the economic benefits per averted birth are about $763,742. Although the population with about 171,000 births averted produces a slower growth rate of GDP in the long run, we still obtain positive economic benefit from this fertility reduction because the population produces a larger GDP for about 60 years than does the normal fertility population. The benefits are high because fertility reduction in the short run leads to a larger GDP, which, in turn, causes further fertility decline. Table 4.15 shows the comparison of economic growth with and without births averted in 1965.

TABLE 4.15

COMPARISON OF ECONOMIC GROWTH WITH AND WITHOUT BIRTHS AVERTED IN 1965

YEAR	POPULATION		GDP		GDP PER CAPITA	
	NORMAL	BIRTH AVERTED	NORMAL	BIRTH AVERTED	NORMAL	BIRTH AVERTED
1965	13.0	12.8	155.6	156.1	12.0	12.2
1970	14.6	14.4	232.8	239.1	16.0	16.6
1970	16.1	15.7	355.0	385.1	22.1	24.5
1980	17.2	16.8	617.8	690.0	35.8	41.0
1985	18.6	18.2	1136.8	1282.4	61.1	70.4
1990	20.1	19.7	2135.0	2378.6	106.1	120.7
1995	21.7	21.2	3754.5	4054.5	173.1	191.5
2000	23.1	22.5	6189.2	6547.2	267.4	290.7
2005	24.4	23.7	9726.6	10092.9	398.1	425.6
2010	25.7	24.9	14541.9	14823.9	566.9	595.9
2015	26.9	26.0	20436.5	20492.3	760.7	787.6
2020	28.0	27.1	27090.0	26708.0	966.1	985.2
2025	29.1	28.0	34337.8	33525.1	1181.1	1195.3
2030	29.8	28.7	42335.8	41007.0	1420.2	1428.9
2035	30.3	29.1	51297.7	49451.3	1693.3	1698.7
2040	30.6	29.4	61675.4	59233.3	2014.7	2014.0
2045	30.9	29.6	72942.9	69609.5	2363.7	2349.7
2050	31.1	29.8	84435.3	80108.9	2718.2	2686.7
2055	31.3	30.0	96260.1	91021.6	3075.2	3029.9
2060	31.5	30.2	108829.2	102733.1	3454.4	3400.0
2065	31.7	30.3	122440.8	115401.6	3867.8	3802.8
2070	31.8	30.5	136798.6	128613.6	4304.2	4221.8
2075	31.9	30.6	151285.6	141820.9	4740.9	4635.6

UNIT: (a) Population: Millions of persons; (b) GDP: billions of 1971 N.T. dollars; and (c) GDP per capita: thousands of 1971 N.T. dollars.

The total economic benefits of the prevented births minus the benefits obtained directly by the participating families equal the benefits obtainable by the country at large. It is nearly $127.11 billion 1971 N.T. dollars. Hence, almost all the benefits are gained by the country at large. However, because the participating families still benefit indirectly from the benefits which accrue to the country in general, there is not a clear-cut distinction here between the benefits obtainable directly by the participating families and those that spill over into the country at large.

Table 4.16 shows a summary of the benefits of the 171,000 births averted in 1965. In brief, total benefits are $130.60 billion, of which $3.49 billion is obtained by the families reducing fertility and about $127.11 billion is obtained by the country at large. The gain per birth prevented is $763,742, of which $20,443 is obtained by each participating family if the averted child would have stayed with the parents after maturity, and $53,889 is obtained by each participating family if the averted child would have left the parents after maturity. Thus, about $743,299 of the total gain is obtained by the country at large.

The estimated gain per averted birth is sensitive to the choices of discount rates and the time span considered. If we compare 20 years of GDP with and without births averted, the economic value per averted birth would be 5,563,500, 2,897,200, 1,559,000, 830,300, and 504,000 respectively when discount rates of 0%, 5%, 10%, 15%, and 20% are used. And if we compare 60 years of GDP, the economic gain per averted birth would be 126,231,100, 19,934,100, 4,950,900, 1,692,900, and 763,100 respectively when discount rates of 0%, 5%, 10%, 15%, and 20% are used (as shown in Table 17).

TABLE 4.16

BENEFITS OF 171,000 BIRTHS AVERTED IN 1965

UNIT: 1971 N.T. DOLLARS

ITEMS	AMOUNT 1971 (N.T.$)
Total benefits:	130.60 billion
(1) Those obtainable by the participating families:	
(i) Child after maturity stayed with the parents	3.49 billion
(ii) Child after maturity left the parents	9.20 billion
(2) Those obtainable by the country at large	127.11 billion
Benefits per birth averted:	763,742
(1) Those obtainable by a participating family:	
(i) Child after maturity stayed with the parents	20,443
(ii) Child after maturity left the parents	53,889
(2) Those obtainable by the country at large	743,299

TABLE 4.17

ECONOMIC BENEFITS PER AVERTED BIRTH

UNIT: THOUSANDS OF 1971 N.T. DOLLARS

	TIME SPAN CONSIDERED				
DISCOUNT RATE	20 YEARS	40 YEARS	60 YEARS	80 YEARS	100 YEARS
0%	5,568.5	50,830.5	126,231.1	146,277.1	-145,420.3
5	2,897.2	13,030.8	19,934.1	20,733.6	18,127.5
10	1,559.0	4,157.7	4,950.3	4,990.9	4,957.4
15	830.3	1,584.8	1,692.9	1,695.5	1,695.0
20	504.0	747.3	763.1	763.7	763.7

CHAPTER 5

SUMMARY AND CONCLUSIONS

Over the past 25 years, Taiwan has had one of the fastest growing populations in the world and one of the fastest growing economies in the world. On the other hand, the rate of fertility reduction has also been one of the fastest. The government has attempted to increase GNP growth rates and, at the same time, to reduce the fertility rate through its family planning program. Both population growth and economic development are among the subjects of most concern in Taiwan.

The purpose of this study has been to examine the effects of three fertility trends--normal, low, and very low--on economic growth and to estimate the economic value of averted births in terms of market goods. To do this a disaggregated economic-demographic model that treats demographic variables as endogenous was constructed. The model presents a set of theoretically valid equations. Labor force participation rates are a function of (1) wage rates and (2) current and past fertility. Per capita food consumption, not per capita income, is used as a proxy for nutrition. Because most investments do not begin to contribute to GNP for the first few years owing to planning and construction time, effective capital input instead of capital stock was used in the production function. The effects of age and sex composition were minimized by using the number of equivalent adult consumers in the consumption function and by setting up equations for age- and sex-specific fertility, survival, and labor force participation rates.

The model, involving a high degree of interrelationship among the variables, is a neoclassical open-economy growth model. Except for the depreciation equation, which was estimated by ordinary least squares, all the behavioral equations were estimated by using the two-stage principal-component method. The validity of the model was evaluated by performing historical simulation. Because the model is non-recursive and includes nonlinear variables, it was solved by the Gauss-Seidel method. The results are all reasonable: (1) the root-mean-square percentage errors are all low regardless of the initial period of the simulation, and (2) the RMS forecast errors are all as small as the RMS percentage errors of historical simulation. In estimating the gains from fertility reduction obtainable by the participating families, (1) the increase in output that would otherwise have been produced by the averted children, (2) the increased output derived from increased female labor force participation, (3) the consumption averted by the fertility reduction, and (4) the difference in consumption patterns by age and sex were taken into account.

To simulate the effects of different fertility trends on the economic growth it was first assumed (1) that some kind of effective family planning program could lower the constant terms of the age-specific fertility equations by 13% from the normal fertility trend; and then (2) that a more effective family planning program could reduce the constant terms of the fertility equations by 32% from the normal fertility trend. In the base simulation, fertility would be at replacement level in 1977; under the first and second assumptions, fertility would have reached replacement level in 1972 and 1967, respectively.

The demographic findings show that, because of the young age structure, even if fertility were to reach replacement level immediately, the population in Taiwan would still increase by more than 94% before it stabilized. The initial demographic effects of fertility reduction are a decrease in the population growth rate, a lowering of the dependency ratio, and an increase in the labor force. Projections for 2025 using the three assumptions about fertility trends show clearly that the very low fertility trend assumption produces the smallest population, the smallest labor force, the smallest number of equivalent adult consumers.

The economic findings indicate that the low and very low fertility trend assumptions eventually produce slightly smaller GDP and smaller GDP per capita than the normal fertility trend assumption. However, the low and very low fertility assumptions generate substantially larger GDP and larger GDP per capita in the near future up to 40 to 60 years. However, if we do not assume that people retire at age 65, GDP per capita need not ever be lower for the LFT and VLFT populations. Also, labor shortage may induce greater technological change, so GDP per capita again may be eventually higher for the two lower fertility trend populations.

If a 10% discount rate is used, the LFT and VLFT populations respectively produce 16% and 26% higher sums of the present values of the annual GDP per capita than does the NFT population. When a 20% discount rate is used, the gain per birth prevented is $763,742 (1971 N.T. dollars), of which $20,443 is obtained by each participating family if averted child would have stayed with the parents after maturity, and $53,889 is obtained by each participating family if the averted child would have left the parents after maturity.

However, the estimated gain per averted birth and the difference in the sums of the present values of the annual GDP per capita are sensitive to the choices of discount rates and the time span considered.

This study yields two important policy implications. First, because lower fertility has immediate economic advantages, it may be beneficial for a developing country with a high birth rate to reduce fertility in order to break out of the low-income "trap" as soon as possible. The normal, low, and very low fertility trend populations all generate very high GDP per capita in the long run. It may, therefore, not be of primary importance that the two lower fertility trend populations eventually produce slightly smaller GDP per capita than does the normal fertility trend population; it may be of much greater importance that they produce much higher GDP's in the next 50 or so years from the economic point of view. For a developing country to break out of poverty such rapid growth may be necessary.

Second, Taiwan's family planning program has not been successful in significantly changing fertility rates even though it has been considered one of the most successful in the world. It may have succeeded very well in disseminating information about methods of contraception and in providing family planning services; yet, the program has not clearly been able to change high fertility motivation except possibly among women aged 30-49. Based on the regression results presented, the program has not been able to reduce fertility measurably faster than the secular trend of fertility reduction caused by other factors. Therefore, to reduce population growth further, it will be necessary to conduct research to find other methods that are better in terms of (1) scientific, medical, and technological availability; (2) political viability; (3) administrative feasibility; (4) economic capability; (5) moral, ethical, and philosophical acceptability; and (6) effectiveness [4].

In many respects, the model considered is more elaborate than its antecedents. Nevertheless, there are still some areas in which the present study might be refined:

(1) We fail to take into account the productivity gains as a function of education, health, research, technology, management, and so on; these have been considered as important sources of economic growth by Leibenstein [56] and Myrdal [67].

(2) The weighting of equivalent adult consumers deserves further study. The weights that should be assigned would undoubtedly be different in different countries and at different points of time.

(3) This model imposes no limit to demographic and economic growth. There must be some point at which further population growth would induce decreasing returns to scale.

(4) There is a time lag from the start of construction of manufacturing plants to completion. Mayer [60] finds that the average time for almost all companies in the United States is about 15 months. We do not have a similar study for Taiwan that would permit us to assign precise weights for net investments in calculating the effective capital stock.

(5) The marginal cost of children declines with parity. But in an aggregate model, the marginal cost of all children is assumed to be the same. Therefore, we overestimate the benefits of averted births to the participating families.

(6) The causes of fertility changes are not yet well understood; in particular, we are not able to predict what will happen to the level of fertility rate after the rate reaches replacement level.

(7) We fail to take into account the consumption of grandchildren. This will not affect the lower bound of the cost, but will reduce the upper bound of cost.

(8) The productivity of labor is affected by the capital-labor ratio; thus, the output that would have been produced by the unborn children will be different at different stages of economic development.

(9) In rural areas in Taiwan, many children under 15 years old already begin to help their parents with farming or family business. This kind of data is not available; therefore, we underestimate the value of children.

(10) This study is concerned only with the potential economic benefits and costs of births averted. Because of difficulties in measurement, it omits (a) non-economic values of averted births such as leisure enjoyed by parents, the better health of mothers and children, and freedom from the emotional and psychological burdens imposed by children; and (b) non-economic costs of averted births such as failing to continue one's family line, and the loss of the joy, companionship, and pride derived from children [29] [91] [122].

(11) This study assumes the retirement age and technology to be fixed. In fact, if we allow them to change in response to income increase and labor shortage, the LFT and VLFT assumptions may generate larger GDP per capita in the long run than the NFT assumption.

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