INTERACTIONS BETWEEN POPULATION GROWTH AND ECONOMIC DEVELOPMENT IN TAIWAN

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ABSTRACT

INTERACTIONS BETWEEN POPULATION GROWTH AND
ECONOMIC DEVELOPMENT IN TAIWAN

By

Paul Ke-chih Liu

This study attempts a theoretical and empirical analysis of the interactions between population growth and economic development. It sets forth an economic-demographic two-sector growth model with special emphasis on the characteristics pertinent to developing countries.

The main conclusions that emerge from an application of the model to Taiwan data for the period from 1951 to 1970, together with the findings of a historical analysis of the population and economy back to 1905, are as follows:

1. The relationships between population growth and economic development in Taiwan have been significantly affected by the institutional factors of international exchange relations, income distribution policies, agrarian systems, and traditional Chinese values.

2. Given the sociocultural and institutional milieu, interactions between population growth and economic development are found to be extensive. The salient results of the multivariate analysis are:

(a) Fertility for women over thirty years of age bears a strong positive association with the proportion of the labor force engaged in agriculture and the ratio of the agricultural to the nonagricultural wage, but fertility for women below age thirty did not respond to these factors as much.

(b) There is a negative correlation between mortality and spending on health care for both sexes at all ages. Per capita income, however, is negatively correlated with mortality only of younger (0-15 years old) and older persons (50 and over) but not with the adult population.

(c) Movement of the labor force from the rural sector is strongly and positively associated with shifts in the pattern of demand from agricultural to nonagricultural products. Such movement relates negatively to the urban-rural wage differential because industrial employers hired fewer workers in response, but the strength of the relation is comparatively weak.

(d) An increase in the size of the population during the period from 1951 to 1970 seemed to increase demand for food, education, health care, and shelter, but to lower demand for services and clothing.

(e) Ceteris paribus, population growth creates much disguised unemployment which depresses the agricultural wage rate more than that of nonagriculture.

(f) An interlocking relationship may be traced from the above findings: as the level and pattern of aggregate demand change, the extent and structure of economic activities adjust accordingly. These induced changes influence the rate of population growth, mainly through fertility, which in turn affects the level and pattern of aggregate demand.

(3) During the period from 1951 to 1970 some of the economic and sociocultural institutions like land reform regulations, nature of the family planning program, services for the elderly, and certain traditional values that might have been conducive to economic development and population modernization probably would have been more

effective if their character and timing had been different. In consequence, interactions between population growth and economic development were confined to certain limited ranges.

The conclusions of this study are useful for the understanding of the conditions and mechanisms of changes in the population and the economy. It is necessary to emphasize, however, that the principal findings -- the numerical parameters of the multivariate analysis -- are strictly applicable to Taiwan in the postwar period only because they are socioculturally and institutionally bound and hence do not necessarily measure demographic and economic relations alone. The general validity of these parameters should be determined by an extensive comparative study of other populations in different institutional environments.

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By

Paul Ke-chih Liu

A THESIS

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To

Professor Ronald Freedman

and

Professor Deborah S. Freedman

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I am, of course, solely responsible for any omissions and errors in the dissertation.

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CHAPTER I. INTRODUCTION

1. Objectives of the Study

The interactions between population growth and economic development of the developing countries have attracted the attention of some economists and demographers for the past decades. The main reason for this is the occurrence of two consecutive demographic events: first, a rapid growth in population owing to a decline in mortality with fertility remaining constant and high; and second, a high rate of urban migration which is in part an effect of the first event. An increase in population growth, with other economic conditions remaining constant, imposes an immediate burden on the economy. The rapid influx of large numbers of people into urban centers creates a series of social and economic problems, such as shortages of public facilities, accommodations, and jobs. In Taiwan the first event occurred approximately in the period from 1945 to 1960, while the second has been felt in recent years.

Substantial knowledge of the consequences and determinants of population trends has been accumulated since the occurrence of the first event. Once believed to be the most problematic factor governing population trends, fertility, which has occupied considerable efforts by academicians and administrators, has gradually been brought under the control of human will in some of the developing countries.

Increasing research on the relation of urban migration and economic development has also been carried out. Relatively little attention has been given, however, to the integration of population growth and urban migration into one general economic analysis. Moreover, as urban unemployment, mainly originating from rapid population growth and migration, has succeeded population pressure on resources as the major policy problem, interest in labor absorption in the developing countries has revived, while few economists and demographers have gone beyond inquiries into the effects of the rate of population growth on economic progress.

The primary objective of this thesis is to study in depth, both theoretically and empirically, the interactions between population growth and economic development in a broader context. First, a macroeconomic-demographic two-sector model is constructed with special emphasis on simultaneous consideration of the components of population growth and their dynamic effects on demographic and economic characteristics of the population. Next, the model is tested with empirical evidence. With the aid of existing knowledge in the fields of economics and demography the job of constructing a logically consistent theoretical model is easier than to find an adequate locale for testing the model. Fortunately, Taiwan is particularly suited to our purpose, because on the one hand it has experienced significant economic and demographic changes since World War II, and on the other this experience has been verbally and statistically documented in a rather detailed form. This, of course, is not to imply that our study is free of constraints of data. In fact, both descriptive and quantitative analyses are important to our study of the interactions

between population growth and economic development.

2. The Problem and the Conceptual Approach

Studies on the interactions between population growth and economic development must involve both economics and demography. The relation between the two disciplines, in the opinion of most economists and demographers, has been rather unstable and even disharmonious. The general trend of development, in W. C. Mitchell's words, is described as:

> Position of population problem in economic theory has undergone radical change. It had been treated by the classical economists as a dynamic factor. As economics became more rigorous and academic it became more static. Population changes had no place in a strictly static analysis. . . . They do not figure prominently even in Marshall. If we are to develop dynamic economics, population must be restored as one of the basic factors in economic theory. Theorists must consider the implications of the prospect of an aging population in respect to characteristics of demand, and also to available supply of labor.[1]

Recent developments in growth theory have verified Mitchell's prediction. There seem, however, to be many unreconcilable obstacles between the two disciplines. In 1957 F. Lorimer stated outspokenly:

> The marriage of demography and economics while both were immature -- "Parson" Malthus officiating -- resulted in a stormy and unfruitful union. Both dynamics of interactions among economic factors and the dynamics of vital trends in relation to population structure were long neglected in a hasty synthesis that placed undue emphasis on the relation of population to resources, and the corollary theory of a theory of a hypothetical fixed "optimum". . . . Both the demographer and the economist have important contributions to make to an understanding of interrelations between population trends and economic changes. But neither encompasses the whole subject within his own field

> of special competence. . . . Yet an analysis of interrelations among such complex economic and demographic process, with attention to their social and cultural context, is essential in a sound approach to this subject.[2]

More recently, massive efforts have been under way to explore the relationships between population change and economic development. Much of this research, however, has still been devoted to the direct relationships between population and resources. D. Kirk pessimistically wrote in 1968 in his encyclopedia article on the subject:

> Dissatisfaction with the Malthusian approach led to the divorce of demography from economics and to a continuing suspicion among some economists that demography overemphasizes the force of population growth and that population control in underdeveloped areas is in some way a diversion from, and even a threat to, the central purpose of economic development.[3]

This brief review of opinions on the relation between economics and demography clearly indicates that disharmony arises not because of the existence of any innate disagreeable characteristics but mainly because of the changes in emphasis on the subject matter of the two disciplines. In order to reconcile economics with demography then, one must first seek well-defined scopes of the two disciplines and then link the subject matter defined therein into an integrating economic-demographic model.

Among students in both fields there are considerable differences of opinion on the proper areas covered by each. This is especially true of demography. Some believe that demography disperses among various disciplines -- economics, history, geography, statistics, sociology, anthropology, and human biology -- and others look upon it as an independent discipline. For our purpose a comprehensive view

free of any preconceived intention of affiliating economics to demography will be most suitable.

According to the above criterion the definition of economics used by W. J. Samuels in "The Scope of Economics Historically Considered" is selected. He circumscribes economics as follows:

> Economics has been historically a discipline of two traditions, Economic Theory and Theory of Economic Policy. Whereas Economic Theory is concerned with market resolution of the three basic economic problems of resource allocation, income distribution, and aggregate-income determination. Theory of Economic Policy is concerned with a fourth problem, the organization of the economic system, ultimately the distribution of power .[4]

For demography Hauser and Duncan's definition best meets our criterion. They define it as follows:

> Demography is the study of the size, territorial distribution, and composition of population, changes therein, and the components of such changes which may be identified as natality, mortality, territorial movement (migration), and social mobility (change of status).5

One of the special features of this definition is the omission of any reference to population quality. This omission, however, has no effect on the construction of our model. For changes in human quality result from investment in human resources which, by definition, belongs to economics.

The basic elements of these definitions can be organized on the basis of modern economic and demographic theory and the interrelationships among them explored. Let us start with the economic problem of aggregate-income determination. The rate of income (output) of the economy at time t is determined by the quantities of inputs -- land, labor, capital, and technology actually used in the production

process -- and by the forces of the specific economic system (the structure of power). Assuming that the production relation between inputs and outputs is homogeneous in the first degree, the function of demand for inputs which relates the marginal physical products of each input to the quantities of that input can be derived. The demand for input functions together with the given functions of supply of input simultaneously determine the economic problem of income distribution in terms of factor prices and the quantities of inputs employed in the production process. If the economy contains several main productive processes, then under the assumption of perfect competition the total available land, labor, capital, and capacity of technology will be allocated among the processes to the point where the values of the marginal products of each input in process are equal to each other.

Population enters the economic complex via its direct influence on capital formation and labor supply. An increase in the size of population through the increase of births over deaths exerts an immediate effect on level and pattern of demand for consumption goods, which in turn affect the capacity for capital accumulation. After certain time lags the increase in population contributes to the supply of the labor force on the one hand and on the other creates the problem of employment. Conversely, allocation of labor among various production processes and changes in level of income have an influence on the movement and mobility of population and then an effect on the trends of fertility and mortality, which in turn affect the size and age-sex composition of the population.

The above brief sketch completes the general picture of the interrelationships between economics and demography. It will be used

as our blueprint for the construction of our economic-demographic model.

3. A Brief Review of the Literature

Ancient studies on relationships between population change and economic growth can be found.[6] Plato and Aristotle both asserted that there was an optimum size of population that would allow a city-state to be capable of self-defense and economically self-sufficient. A large and growing population was favored by the Mercantilists for its economic, political, and military advantages to the nation. More recently Adam Smith also argued that a large population would benefit the economy by supporting a large market and extensive division of labor. The view on population expressed by Malthus in his First Essay on Population 1798 has had great influence on economics and related subjects. It states that population tends to grow faster than the means of subsistence and thus to erode economic progress if not checked by vice, misery, or moral restraint. This conclusion, however, was arrived at by Malthus from a demographic point of view, not from his view of economics or population studies. Malthus made this point clearly in the Essay and in his Principles of Political Economy. He said that the purpose of the Essay was to "trace the cause which practically keeps down the population of a country to the level of its actual supplies,"[7] while the object of the Principles "is to show what are the causes which chiefly influence these supplies."[8] In the Principles Malthus claims that under a system of common property the production of food and the increase of population might go on until the soil absolutely refused to grow a single additional plant. In

this situation, the total society would be exclusively engaged in procuring the necessities of life. But under a system of private property with political liberty and popular education, the profit motive of the landlord would bring land under cultivation only to the extent that the returns would be sufficient to pay for the maintenance of labor and a profit for him. The profit would allow this class to support the progress of the arts and sciences. The benefit from this diversion is so significant that "the effect of taking poorer land into cultivation is likely to be counterbalanced under such circumstances, that in the actual state of many countries, or in their probable state of many centuries to come."[9] At the same time this system "tends to elevate the character of the lower classes of society, which makes them act as beings who 'look before and after,' and consequently cannot acquiesce patiently in the thought of depriving themselves and their children of the means of being respectable, virtuous, and happy."[10]

It is seen that in the Essay Malthus compared the natural power of mankind to increase with the actual power of increasing produce from the soil, while in the Principles he investigated the causal relation between the actual supplies of product determined by the effectual demand and the actual growth of the labor force (population) in the particular circumstances of the society. Obviously the conclusion based on the former is a tautology and that based on the latter is Malthus' economic theory of population.

In his Principles of Economics Alfred Marshall had developed a dynamic system of population supply and demand in line with his classical predecessors.[11] After Marshall population economics flourished with the impulse of population effects on the economy. Optimum

population theory prevailed around the turn of the century. During the 1930s the Keynes-Hansen stagnation thesis dominated the academic cycle of economics, and thereafter economic-population development theory surpassed them all and thrives to the present time. The optimum population theory is mainly concerned with finding the size of population which would maximize the average or marginal products of labor, given that all other factors remain constant. The stagnation theory states that population growth is one of the important elements in economic progress. Hansen estimated that 40 to 60 percent of the total capital formation in the western countries during the nineteenth century was due to population growth.[12] Decline in population growth thus causes a deficiency in effective demand for investment goods and in turn, a slowdown in the pace of economic development.

Since World War II economists have been largely concerned with the problems of population and economic development in the developing countries. Kuznets, and then Coale and Hoover, chose several courses of fertility trend arbitrarily and worked through a simple and closed Harrod-Domar model to demonstrate the differential effects of alternative changes of fertility levels on economic growth.[13] Nelson and Hagen compared the rate of population growth with the rate of increase of per capita income and studied the interrelation between these two variables.[14] Leibenstein went further in attempting to make the population factor an endogenous variable in a growth model and developed his minimum critical effort theory.[15] Lewis, Fei and Ranis, and Harris and Todaro constructed two-sector models to demonstrate the workings of urban-rural migration and economic growth.[16] Clark, Hirschman, and Boserup may be the only exceptions in considering the growth of

population a stimulant rather than an obstacle to development of economically backward countries.[17] Enke and Zind, Lloyd, and Barlow and Davies evaluated the effects of government projects on population and economic growth with the use of economic models.[18] Sauvy and Votey modified the economic optimum population theory by considering power and preference for children in the welfare function.[19] Easterline followed Malthus, Keynes, and Hansen in attempting to elucidate the role of effective demand in the relation between population change and economic activities.[20]

This brief review indicates that many specific economic-demographic relationships have been investigated. Some of these investigations have been conducted in a general equilibrium framework, but any single work can be viewed as a partial equilibrium analysis in light of important relationships treated in other models. In sum, then, it can be stated that there is a need to integrate features of individual models into a single complex of variables that consists of a general equilibrium framework in the sense that it does not omit important economic-demographic interactions.

4. Sources of Data

The data for this study are drawn primarily from three sources which are described more thoroughly in the pages that follow: (1) national income statistics compiled by the Directorate-General of Budgets, Accounts, and Statistics, Executive Yuan (DGBAS), (2) population and vital statistics derived from the population register, and (3) labor force statistics from surveys conducted by the Labor Force Survey and Research Institute.

NATIONAL INCOME STATISTICS Compilation of national income statistics is relatively new in Taiwan. Annual estimates have been made available by DGBAS since 1951. Basic concepts and methods of compiling Taiwan's national income closely follow the National Account System suggested by the United Nations.[21] Unfortunately, the reliability of the statistics for 1951 to 1964 is questionable, mainly because many of the items for that period, such as imputed rent for owner-occupied dwellings, values of agricultural by-products, and depreciation of government buildings, were estimated in 1967 to 1969 and added to the reports for the respective years. Estimates made in retrospect inevitably involve guesswork and arbitrary assumptions. These adjustments are necessary, however, to make the time series of national income statistics comparable.

POPULATION AND VITAL STATISTICS Demographic data can be obtained from the population censuses of 1956 and 1966 and statistics compiled from the continuous population register.[22] The latter gives yearly population and vital statistics in great detail and their accuracy and completeness are not inferior to those from the general population censuses. Therefore, we rely mainly on the second source.

The continuous population register has operated since 1905. The hierarchy of registration is parallel to the civil divisions. A registration office is affiliated with each government of a township, a precinct, or a small city. The office, staffed approximately by one clerk for every 4,000 population, is responsible for keeping the registers. The basic unit of registration is the household. Each household must file a "Household Record" in the registration office located near its residence, and keeps a roster of all members and an

"Identification Card" for each person above 14 years of age for the purpose of cross-checking. These papers also serve as legal proof of identity, family relationships, citizenship, and civil or public privileges and obligations. The head of each household is responsible for reporting changes in demographic events of and within the household. Births, marriages, and migration must be reported within 15 days after occurrence and death within 5 days. The registration entries include the relationship to the head of the household, the domicile, the birth date, the birth order, the marital status, the education, and the occupation. For each person blanks are reserved for entering migration, military service, and criminal records. Births, deaths, marriages, changes in education or occupation, divorces, and population movements are recorded on special forms before appropriate entries or changes are made on the Record. Population and vital statistics are compiled by local offices from the information on Household Records and on the special forms. The tabulations are population by age and sex, by education, by occupation for each sex; births by age of mother and father; and deaths by age and sex. Copies of tabulations are sent to Taiwan provincial and Taipei city general registersfor final checking and publication.

The registers are checked at the end of each year by a canvass. The census also functions as a thorough check of the registers. There have been relatively few omissions or duplications of events required to be registered. The system, however, is not necessarily perfect. There are three main sources of error: (1) errors in the completeness of registration, (2) errors in the registered characteristics, and (3) errors in data processing. Each type of error is briefly discussed

as follows.

Errors in the Completeness of Registration One serious flaw, from the user's point of view, is the deliberate omission of military personnel from the published figures. It has been estimated that a military force of about 600,000 moved into Taiwan around 1950. This accounted for about one-tenth of the population at that time. All except those personnel who had families and resided outside the barrack areas were omitted from the registration system for administrative reasons. Thereafter the size of the armed forces has been maintained through recruiting civilian youth for two or three years of service. The retired servicemen are reported in the register. Although the recruits remained in the record, they did not appear in the published population figures until 1961. In 1969 the military forces moved into Taiwan around 1950 from the Mainland and not retired were also included in the register. For these reasons the published figures for the total population of Taiwan for the years before 1969 are incorrect. To provide consistency in this study estimates of total population for each year from 1951 to 1968 were made in the following manner. The population by age and sex in 1970 was used as a base population and projected backward by reverse survival ratios, thus including the civilian population plus the survivors of the 1950 military forces.

A second problem of the completeness of registration is delay in reporting population movement and vital events. There have been no major movements of population in and out of Taiwan since 1951. The small stream of in and out movement, largely students going abroad for advanced studies, was quite accurately reported. Delays in reporting movements within the island create problems for population counts in

local areas. In our study, however, only total population by age and sex was used, therefore errors in this respect have no effect on the numerical results of our study.

Deaths of persons over five years of age were reported fairly accurately and the reports were made on time. Studies on the accuracy of the registration of deaths found that mortality rates for those five and over were in high agreement with model life table rates.[23] Evaluation studies all showed that of the total number of deaths registered in 1965, 96 percent were registered within a month after the date of occurence. Deaths of infants soon after birth are found to be underregistered throughout the island. This kind of error affects the accuracy of the infant mortality rate more than it does the completeness of total counts, so no adjustment was made in total counts. Infant mortality rates were estimated by extrapolating the mortality rate of persons 5 to 9 years old in accordance with the relation established by the appropriate model life table.[24]

Registration of births, except for the case just mentioned, was fairly accurate, although late reporting of births was not uncommon. In 1968, 83 percent of the births were reported within a month. No improvement has been reported since then. In fact, the percentage of birth reporting within a month decreased to 81 percent in 1971.[25] If the pattern of late reporting does not change significantly, annual counts of population will not be seriously affected.

Errors in the Registered Characteristics The accuracy of age registration has never been a serious problem in Taiwan, due to the fact that age is calculated from the registered date of birth rather than obtained from direct questioning of persons. The procedure used

avoids the problems of inaccurate declarations of age and of preference or avoidance of certain digits. However, a minor defect found in an evaluation survey made in 1965 is that some older persons tend to give birth dates according to the lunar calendar.[26] This yields a one- to two-month difference from the standard solar calendar.

The accuracy of the education and occupations registered must be seriously questioned. The 1965 check survey indicated that the percentage of persons with accurate education and occupation entries in the registers was 91 and 82 percent respectively.[27] The errors in education and occupation registration were not the result of misreporting: they were mainly due to failure to keep information up to date. Since producing education and occupation tabulations is not the primary function of the registration system, registrars and the heads of households were not urged to make such corrections. In response to demands from academic circles, a general check and corrections for these entries were made in 1968.[28] Measures to keep the registration entries up to date were also implemented. Our study needs a time series of education and occupation classifications for the labor force, and adjustment for these data would be difficult, therefore we have to rely on other sources described in this Chapter for this kind of data.

Errors in Data Processing The township or precinct registrars are responsible for preparation of tabulations from their registration records for three time intervals in a year. At the beginning of each month the total number of households, the population by sex at the end of the preceding month, and the registered births, deaths, marriages, in and out migrants during the month are counted. Every three months the registered births are classified by age of mother and

father, and by fathers' occupations; and the registered deaths by age and sex. At the end of the year information on the household record is used to make tabulations of population by age and sex, by education, and by occupation for each sex. All the work is done by hand tally by the clerks in township offices under the supervision of registrars at county, city, and provincial governments. Mistakes made during the process of tabulation are considered to be fairly few. A re-count of the registered births and deaths in 1965 shows that the total differences between the original count and the re-count in each county or city have not exceeded the range of 2 percent.[29] A serious defect, however, has been found in the tabulation of deaths of infants and children. Most deaths of infants below age one registered during the year are misclassified into the group for ages one to four. This is partly due to delays in reporting deaths but mainly due to the Chinese custom of adding one year to each person's age on New Year's day, e.g., an infant born on New Year's eve will be two years of age the next morning. This defect again rules out the usefulness of the published data on infant and childhood death for purposes of this study.

LABOR FORCE STATISTICS Labor force statistics that are more detailed than those derived from the register are found in the reports on labor force surveys prepared quarterly since October 1963 by the Taiwan Provincial Labor Force Survey & Research Institute. The primary objective of the survey is to collect current information on characteristics and employment situation of the civilian population over fifteen years of age. The labor force, in the reports, is defined as persons over fifteen who are able and willing to work in the production of economic goods and services. Employed persons are those who worked

at least one hour for pay or profit, or who worked fifteen hours or more as unpaid family workers during the week including the fifteenth day of the survey month. The population is selected by a two-stage sample procedure. For example, in the survey of October 1970 in the first stage six precincts from Taipei city and six small cities were randomly chosen. The remaining 349 administrative districts (townships, small cities, and city precincts) were divided into 43 strata according to (1) the population density, (2) the industrial composition of labor, and (3) the employment rate. Two of the administrative districts in each stradum were selected with a probability proportional to size. A total of ninety-eight districts was selected. In the second stage households were randomly selected from the selected districts until the sample of the population above fifteen included in the survey was two per thousand of the total population.

The representativeness of the survey data can be directly evaluated by comparing the estimated total population over age fifteen, the total number of employed persons, and the persons employed in agriculture and nonagriculture, with those from the population register. Statistics from the register represent conditions enumerated at the end of the year, while the estimates of the survey reflect conditions at the end of the week including the fifteenth day in October; therefore the magnitudes of the former tend to be greater than the latter. It can be seen from Table 1.1 that the survey estimates of population over age fifteen and of employed persons were no more than 5 percent lower than those for the whole population enumerated from the register. The range of the differences did not exceed the value of one standard error.[30] Judging from the results of registration

TABLE 1.1. COMPARISON OF POPULATION AND LABOR FORCE FIGURES FROM LABOR FORCE SURVEYS AND THE REGISTERS

	Civilian Population 15 and over			LABOR FORCE								
				Total			Agricultural			Nonagricultural		
	Registered	Survey	Ratio*	Registered	Survey	Ratio*	Registered	Survey	Ratio*	Registered	Survey	Ratio*
1964	6,685	6,532	.977	3,710	3,520	.949	2,010	1,854	.922	1,700	1,666	.980
1965	6,961	6,736	.968	3,755	3,588	.956	2,017	1,595	.791	1,738	1,993	1.147
1966	7,281	6,983	.959	3,870	3,689	.953	2,050	1,613	.787	1,820	2,076	1.141
1967	7,542	7,268	.964	4,130	4,019	.973	2,043	1,695	.830	2,087	2,324	1.114
1968	7,856	7,520	.957	4,337	4,226	.974	2,144	1,606	.749	2,193	2,620	1.195
1969	8,306	7,939	.956	4,920	4,500	.915	2,226	1,705	.766	2,694	2,795	1.037
1970	8,850	8,206	.927	5,020	4,508	.898	2,243	1,587	.708	2,777	2,921	1.052

SOURCES: Provincial Department of Civil Affairs, 1970 Taiwan Demographic Fact Book (Nantou: 1971), and Provincial Labor Force Survey and Research Institute, Quarterly Report on the Labor Force Survey in Taiwan, No. 30, January 1971.

*Ratio of Survey to Registered.

evaluation we may conclude that both sets of data are of high quality. The large differences seen in the figures for persons employed in agriculture and nonagriculture reaffirm the fact that the registers had failed to keep their records up to date in a rapidly industralizing economy.

5. Plan of Presentation

In this Chapter, we have discussed the objectives of the study, the problem and the conceptual approach, the related studies, and the nature of the data to be used in this study. The following chapter is devoted to the construction of an economic-demographic two-sector growth model. In Chapter III we shall describe the history of the population and economy of Taiwan in order to show the significance of sociocultural and institutional factors in determining the relationship between population growth and economic development. Chapter IV presents and interprets the empirical regression results from the application of our model to Taiwan in the period from 1951 to 1970. In conclusion, Chapter V summarizes the basic findings of the study and discusses their implications for population and economic policies and for further research regarding the generalization of the empirical results from this study.

Footnotes

[1]W. C. Mitchell, Types of Economic Theory, from Mercantilism to Institutionalism, Vol. II, (New York: A. M. Kelley, 1969), p. 764.

[2]F. Lorimer, "General Survey," in D. V. Glass, ed., The University Teaching of Social Sciences: Demography (Paris: UNESCO, 1957), p. 21.

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CHAPTER II. THEORETICAL FRAMEWORK OF AN ECONOMIC-DEMOGRAPHIC MODEL

1. Introduction

The basic aim of this chapter is to build an explanatory model for the analysis of the interactions between population growth and economic development, with application to developing countries like Taiwan especially in mind. Economic development has been seen as "the realized capacity of a country's economy to generate significant and sustained rises in per capita product."[1] To enlarge the capacity of the developing countries involves a transition from a traditional rural to a modern industrial economy. Changes in the level and pattern of aggregate demand and the ability of the economy to supply these new needs provide the force for the transition. The size and composition of the population affect the demand and productive capacities in many respects. The latter again interact with the dynamics of the population.

To trace these interlocked chain reactions we first attempt to formulate an aggregate production function to show the structural transition. This production function is then used in conjunction with the market forces governing the supply of and demand for productive factors and commodities to detect the economic and demographic effects on capital accumulation and employment. Finally, we will be in a position

to analyze the interactions of population growth and economic development.

2. Resource Allocation between Sectors

The economic system consists of two sectors: agricultural and nonagricultural. The former is characterized by traditional and the latter by modern economic features. It is assumed that in both sectors the production functions are linear homogeneous, i.e., subject to constant return to scale. Owing to the resource limitations of the island economy and the rigidity of the social and economic systems, inputs of the two sectors are different in nature and quality. In the agricultural sector, land and its improvement are considered to constitute a portion of the capital stock.[2] Investment in farm equipment is mainly made by owners of the farm; improvement in quality has largely been capitalized in the costs. The quality of labor inputs is likely to remain more or less constant because of the outflow of well-educated young men from farm to industrial work. The introduction of new varieties of seeds, new methods of land utilization, and efficient methods of organization, however, brings in neutral technical progress. The gross domestic agricultural product (GDPA) and product per employed worker (gdpa) may be expressed as

$$(1) \qquad GDPA = Ae^{\tau_a t} LA^{\alpha} KA^{1-\alpha}$$

$$(1a) \qquad gdpa = Ae^{\tau_a t} ka^{1-\alpha}$$

where KA and LA stand for the total amount of capital and labor employed in agriculture respectively; ka stands for amount of agricultural capital stock per worker. A is an arbitrary constant and t is the time trend. The parameter α is the elasticity of agricultural output with

respect to labor input. Under perfect competition it is also the relative share of labor input. $1 - \alpha$ represents those same characteristics with respect to capital input. τ_a is the rate of neutral technical advance in the agricultural sector.

In contrast to the capital stock employed in the agricultural sector, that used in the nonagricultural consists mainly of equipment and plant. The investors in this sector benefit from the free choice of efficient equipment in the world market. Due to technological advance in the developed countries new capital goods procured in any given year are generally more productive than capital goods procured the year before. This is equivalent to the familiar concept of embodied technological change. For the sake of simplicity in mathematical manipulation, it is assumed that capital stock in efficiency units in the nonagricultural sector (KNE) grows at an exponential rate (τ_{kn}) so that

$$(2) \qquad KNE = KNe^{\tau_{kn}t}$$

where KN represents capital stock measured in constant dollars in the nonagricultural sector.

Labor input measured in natural units (man years) in the nonagricultural sector improves over time at an exponential rate (τ_{ln}). This improvement may come either from the training of employed workers or from new entrants with better education, skills, and ability. The labor input in terms of efficiency units (LNE) is then given by

$$(3) \qquad LNE = LNe^{\tau_{ln}t}$$

The introduction of new methods in management and organization benefits general productivity. It is thus a kind of neutral technical progress. Assuming that it grows at an exponential rate of τ_n, the

production of the gross domestic product in the nonagricultural sector (GDPN) may be written as

$$(4) \qquad GDPN = Be^{\tau_n t} LNE^{\beta} KNE^{1-\beta}$$

where B is an arbitrary constant. β and $1-\beta$ are the output elasticities with respect to labor and capital respectively.

Substituting equations (2) and (3) into (4) we obtain

$$(4a) \qquad GDPN = Be^{(\tau_{ln} + \beta\tau_{ln} + (1-\beta)\tau_{kn})t} LN^{\beta} KN^{1-\beta}$$

In terms of output per employed worker (gdpn), (4a) may be expressed as

$$(4b) \qquad gdpn = Be^{(\tau_n + \beta\tau_{ln} + (1-\beta)\tau_{kn})t} kn^{1-\beta}$$

Assuming perfect competition, then the owners of labor and capital earn their respective values of marginal product in each sector.

$$(5) \qquad wa = \partial GDPA/\partial LA = \alpha\,(GDPA/LA)Pa = \tau\, Ae^{\tau_a t} ka^{1-\alpha} Pa$$

$$(6) \qquad ra = \partial GDPA/\partial KA = (1-\alpha)(GDPA/KA)Pa = (1-\alpha)Ae^{\tau_a t} ka^{-\alpha} Pa$$

$$(7) \qquad wn = \partial GDPN/\partial LN = \beta(GDPN/LN)Pn = \beta\, Be^{\tau_o t} kn^{1-\beta} Pn$$

$$(8) \qquad rn = \partial GDPN/\partial KN = (1-\beta)(GDPN/KN) = (1-\beta)Be^{\tau_o t} kn^{-\beta} Pn$$

where wa, ra, wn, and rn, respectively, stand for wage rate and rate of capital return in either sector; Pa and Pn stand for the relative prices of agricultural and nonagricultural output; and τ_o stands for $(\tau_n + \beta\,\tau_{ln} + (1-\beta)\tau_{kn})$.

Under perfect competition conditions, equations (5) and (7) are also the labor demand curves. Manipulation of these two equations makes it possible to represent the proportion of employed nonagricultural workers in total employment (ρ_{ln}) as

$$(9) \qquad \rho_{ln} = LN/LD = \frac{1}{1 + \frac{\partial(wn/Pn)\rho_a}{\beta(wa/Pa)\rho_n}}$$

where LD stands for total number of employed man years; ρ_α and ρ_η stand for the proportions of agricultural and nonagricultural output,

respectively, in total output; and $\rho_a + \rho_n = 1$.

If labor can be transferred freely from one sector to another and no sector has reached the state of zero marginal product of labor, equation (9) gives some insight into how employers in the economy decide to deploy the relative amounts of labor in the two sectors within the limits of the existing distribution of the capital stock. Given the product elasticities of labor in each sector (∂ and β) as data, the proportion of nonagricultural workers hired by the employers is inversely related to the ratio of nonagricultural wage to agricultural wage and positively related to the output proportion ratio, viz., ρ_n/ρ_a.

The first portion of the result seems to be contradictory to the rationale and empirical findings of internal migration because there it is proved that the positive difference between urban and rural wages is the main pulling force causing the redistribution of workers from farm to nonfarm. Both statements are valid, for equation (9) tells how employers will act, while the migration studies illustrate how people respond to a difference in wage rates.[3] When the wage difference exists the economy is in disequilibrium and both employers and workers adjust their respective demand and supply. Only with the attainment of equilibrium (wa = wn) will both of them complete their profit maximizing adjustments and migration cease.

Now assume that both labor and capital can be moved freely between sectors according to the profit maximization principle. Then, in equilibrium the wage rate and rate of capital return in each sector will be equal, i.e., wa = wn = w and ra = rn = r. (Where w and r stand for aggregate equilibrium wage rate and rate of capital returns.)

Assuming again that there exists an aggregate production function, then w and r represent the equilibrium values, respectively, of the marginal product of labor and capital in the production function. Aggregate output is a function of total capital stock per worker (k); consequently, w and r are also functions of k. Denoting the aggregate wage-rental ratio as h, then h is a strictly increasing function of k, that is

$$(10) \qquad h = h(k), \quad h' > 0$$

Given any arbitrary aggregate k_o, the optimum capital-employment ratio in each sector, and thus the division of labor and capital, and the proportion of output, are uniquely determined, i.e., equations (5) through (8) give

$$(11) \qquad ka = (1 - \alpha)\, h\, (k_o)/\alpha$$

$$(12) \qquad kn = (1 - \beta)\, h\, (k_o)/\beta$$

An aggregate production function for a two-sector model that comprises explicitly the relation of changes in the allocation of resources between sectors is not only helpful in determining the wage-rental ratio but is also a useful analytical tool for better investigation of the process of economic development. The literature has been silent about the formulation of such a production function. Attempts made here are far from satisfactory: nevertheless, they can be used, with some inconvenience, for our purpose of constructing an economic-demographic model. The procedures adopted to derive the aggregate output function are as follows.

By definition total domestic gross product is the sum of agricultural and nonagricultural gross outputs. The growth rate of total product is then

$$(13) \quad GDP = \rho_a \hat{PaGDPA} + \rho_n \hat{PnGDPN}$$
$$= \alpha\rho_a \hat{LA} + \beta\rho_n \hat{LN} + (1-\alpha)\rho_a \hat{KA} + (1-\beta)\rho_n \hat{KN} + T$$

The circumflex attached to a variable represents the growth rate of that variable, i.e., GPD = dGDP/ dt / GDP, etc. T represents the technical progress effects on the growth rate of total product, namely

$$(14) \quad T = \tau_a + \tau_n + \beta\tau_{ln} + (1-\beta)\tau_{kn}$$

Assume that the aggregate production function at any given moment in time is also of the Cobb-Douglas type and the output elasticities of labor and capital are functions of time t, as

$$(15) \quad GDP = He^{\tau t} LD^{a(t)} K^{b(t)}$$

The growth rate of total output derived from this production function is

$$(16) \quad \hat{GDP} = a(t)\hat{LD} + b(t)\hat{K} + \tau + \dot{a}(t)\ln LD + \dot{b}(t)\ln K$$

Disaggregating the growth rate of the total employed labor and capital into sectors, we have

$$(16a) \quad GDP = a(t)\,\rho_{la}\,LA + a(t)\,\rho_{ln}LN + b(t)\,\rho_{ka}KA$$
$$+ b(t)\,\rho_{kn}KN + a(t)\ln LD + b(t)\ln K$$

From (13) and (16a) we obtain

$$(17) \quad (\alpha\rho_a - a\rho_{la})\hat{LA} + (\beta\rho_n - a\rho_{ln})\hat{LN} + ((1-\alpha)\rho_a - b\rho_{ka})\hat{KA}$$
$$((1-\beta)\rho_n - b\rho_{kn})\hat{KN} + T - (\tau + \hat{a}(t)\ln LD + \hat{b}(t)\ln K) = 0$$

Assuming that the growth rates of labor force and capital accumulation in neither sector are equal to zero, the parameters of the aggregate production are thus determined

$$(18) \quad a(t)_1 = \alpha\rho_a/\rho_{la} \quad \text{or} \quad a(t)_2 = \beta\rho_n/\rho_{ln}$$

$$(19) \quad b(t)1 = (1-\alpha)\rho_a/\rho_{ka} \quad \text{or} \quad b(t)_2 = (1-\beta)\rho_n/\rho_{kn}$$

(20) $\tau = T - (\dot{a}(t)\ln LD + \dot{b}(t)\ln K)$

Substituting (9) and (10) in (18) and (19), respectively, we get

(21) $a(t)_1 = \alpha\rho_a + \beta\rho_n wa/wn$ or $a(t)_2 = \beta\rho_n + \alpha\rho_a wn/wa$

(22) $b(t)_1 = (1 - \alpha)\rho_a + (1 - \beta)\rho_n ra/rn$

$b(t)_2 = (1 - \beta)\rho_n + (1 - \alpha)\rho_a rn/ra$

Now we may rewrite the aggregate production function of our two-sector model as

(23) $GDP = He^{\tau t} LD^{\alpha\rho_a+\beta\rho_n wa/wn} K^{(1 - \alpha)\rho_a + (1 - \beta)ra/rn}$

From this equation it is seen that the aggregate output of a dualistic economy depends not only on the amount of productive inputs and technical progress but also on the proportion of economic activities and the remunerate ratios of labor and capital between the two sectors.

When resource allocation between sectors has approached optimum equilibrium wa = wn, ra = rn, $\dot{a}(t) = 0$, $\dot{b}(t) = 0$ and for a given wage-rental ratio, for example, h_o, there are corresponding equilibrium values of the proportions of economic activities, i.e., ρ_{no} and ρ_{ao}. Since the wage-rental ratio is a function of the overall capital-employment ratio, the aggregate production function (23) under sectoral equilibrium conditions reduces to

(23a) $GDP = He^{\tau t} LD^{\alpha\rho_a + \beta\rho_n} K^{1-\alpha\rho_a - \beta\rho_n}$

It is a linear homogeneous function, and therefore may be expressed in per-employed-worker terms, that is

(23b) $gdp = He^{\tau t} k^{(1 - \alpha\rho_a - \beta\rho_n)}$

Note that in sectoral equilibrium the aggregate output elasticities of labor and capital respectively are (1) the activity proportion weighted averages of the output elasticities of the two sectors and (2) the

return to scale changed from decreasing returns to constant returns. The remunerate rates for labor and capital are also equal to their weighted averages.

3. The Relation between Population, Employment, and Economic Development

a. Population, Labor Supply, and Employment

The available labor force is governed by the size of the population, its age-sex composition, and the pattern of participation. The components of population growth--fertility, mortality, and external migration--determine the size and characteristics of the population. Since large-scale international migration is not likely to occur in Taiwan given current political circumstances, fertility and mortality are the main factors that determine population trends. Empirical evidence suggests that two components, population growth and changes in patterns of participation, are functions of economic development. As a result, economic development is the main factor determining the size of the labor supply. We shall examine fertility, mortality, the natural growth rate of population, and labor supply and employment.

FERTILITY The existence of the relationship between fertility and economic development has long been recognized in the economic and population literature. Conclusions on the strength and direction of associations, however, are rather confused.[4] The main source of ambiguity seems to be the insufficient specificity of the definition of economic development. As a rule, economists use per capita output or income as an index of economic development. This aggregate measure represents not only the level of purchasing power, but also the concomitant

changes in economic activities, structures, and income distribution, which do not necessarily occur in the same direction or with the same force as growth in per capita output. Fertility trends are related to changes in the whole complex of variables. The influence of any one or any subset of the variables cannot be a proxy for the influence of the whole. The aggregate production function for the two-sector model developed in the previous section may be used to illustrate this point. From (23) it is seen that per capita output depends not only on technological change and productive capacity but also on proportion of product, ratio of wages, and rate of return on capital in each sector. The functional relationship between fertility and economic development therefore should be a function of all these variables, namely,

$$(24) \qquad F = F(\tau, k, \rho_n, wa/wn, ra/rn)$$

where F is the vector of age-specific birth rate for all women between age x and x + n, i.e., $F = \{{}_nF_x\}$. This measure of fertility is free from the effects of changes in the sex and age structure of the population.

The rate of change in fertility is then

$$(25) \qquad \hat{F} = \varepsilon_{f\tau}\hat{\tau} + \varepsilon_{fk}\hat{k} + \varepsilon_{fn}\hat{\rho}_n + \varepsilon_{fw}wa/wn + \varepsilon_{fr}ra/rn$$

where ε_{ij} stands for the elasticity of i with respect to j, e.g., ε_{fk} is the elasticity of the age-specific birth rate with respect to the productive capacity of the economy $(\alpha F/\alpha t/\alpha k/\alpha t)$ (k/F).

It is obvious that changes in fertility level depend on the signs and relative weights of the rates of growth of fertility determinants and fertility elasticities with respect to these determinants. The growth rates of technological progress and per capita productive capacity are both positively related to per capita total output, i.e.,

the index of economic development. The growth rate of the proportion of nonagricultural output in total production, and the respective ratios of the remunerate rate of labor and capital are also positively related to per capita output. The rate of this growth rate is decreasing if an agricultural eonomy is nearing an industrial one. When development has resulted only from an increase in agricultural production or if development has already attained maturity (i.e., fulfillment of sectoral equilibrium), the growth rates of these determinants become zero.

According to the nature of their influence on fertility, the elasticities of technological progress may be decomposed into three types. First, among the elements contributing to the increased productivity of agricultural and nonagricultural output, τ_a and τ_n, the advance in medical science and public health is no doubt of the greatest importance. These advances affect the level of infant and child mortality and the introduction of efficient methods of contraception as well. As these mortality levels decrease, couples who want to achieve the goal of a certain desired number of adult children need fewer births to do so. The introduction of efficient inexpensive contraceptives facilitates the achievement of their goal. Therefore, this kind of technological progress (labelled as τ_1) has a negative effect on fertility as long as the desired is lower than the actual number of children for the population as a whole.

The second type of technological progress (τ_2) consists of increases in the efficiency of labor <u>per se</u>, i.e., τ_{ln}. Such progress obviously originates from a rise in educational levels. Empirical evidence uniformly suggests an inverse relation between educational

level and fertility; therefore, the fertility elasticity of τ_2 is negative.[5]

The remaining elements of aggregate technical progress may be grouped under the third type (τ_3). They effect an increase in the total output that is equivalent to an increase in the productive capacity of the economy. The sign of the fertility elasticity of τ_3 will be in the same direction as that of productive capacity. Therefore we turn to a discussion of the latter.

The term, the productive capacity of the economy, as used here expresses a narrower than usual sense that indicates the amount of capital at the disposal of each employed worker. A change in the productive capacity thus implies a corresponding change in the standard of living as well as in prospective future disposable income. Therefore, the productive capacity connotes the "permanent income" or "potential income," which is more pertinent to fertility decision-making than is income at a given point in time.[6] In low income countries an increase in k (total capital stock per worker), as observed by classical and neoclassical economists, increases the marriage rate, improves health conditions, and consequently raises the birth rate.[7] In high income countries the effects of classical determinants may not be as important as in low income countries but the factor recently discussed by Becker -- the function of children as consumer durables -- is likely to be increasingly influential as income grows.[8] Moreover, annual observation of the adjustment of the timing of births in response to economic conditions has also strengthened the belief in the positive income-fertility relation. On the whole, we may assume that the fertility elasticity of productive capacity is positive.

The well-established inverse correlation of fertility with industrialization may be appropriately applied to the explanation of the negative sign of the fertility elasticity of proportion of non-agricultural output, for the latter is one of the best measures of industrialization. It should be emphasized, however, that changes in economic activities from agricultural to nonagricultural and changes in life styles from rural to urban provide a favorable environment for the spread not only of birth control but also of attitudes favorable to smaller family size.[9]

The ratios of the remunerate rates for labor and capital respectively, (wa/wn), (ra/rn), and the implicit equilibrium value of the total wage-rental ratio (h) may be viewed as indicators of income distribution. The values of the first two indicators are probably between zero and unity -- the larger the value the more equally distributed is the income. The effects of income equality on fertility have recently attracted the attention of both economists and demographers.[10] Because of the lack of statistical data empirical evidence for the exact relation is still insufficient. In an industrializing economy if the increased income were distributed to a relatively small portion of the urban population, the positive income effect on fertility would be relatively smaller than if the increased income were evenly distributed among the general population. Therefore, we may assume a negative relation between fertility and income inequality.

In sum, the signs of fertility elasticities with respect to determinants contained in the fertility function remain the same throughout all stages of development. The growth rates of these determinants, however, vary with changes in economic structure and income distribution

as the economy evolves from an agricultural to an industrial base. Consequently, the effect of economic development on fertility varies in direction at each stage of development. The directions of individual elasticities and the combined effect at various stages are presented in the following:

Fertility elasticity of	Agricultural development	Industrial development	Mature economy
Technical Progress $\tau 1$	-	-	0
Technical Progress $\tau 2$	0	-	-
Technical Progress $\tau 3$	+	+	+
Productive Capacity	+	+	+
Income Inequality	0	-	0
Economic Structure	0	-	0
Combined Effect	+	-	$\pm$

The combined effect of economic development on fertility obviously depends on the relative weights of opposing forces. In the agricultural development stage of Malthus' and Ricardo's time, the medical techniques developed for limiting infant deaths and controlling family size were inadequate. The positive influence of productive capacity dominated fertility trends. On the other hand, the introduction of efficient inexpensive methods of birth and death control in the developing countries may outweigh that positive effect even in a peasant economy. When an economy begins developing industrially the negative effects of industrialization, income inequality, decline in infant mortality, and spread of family limitation gradually gain momentum and tend to outweigh all the positive effects resulting from the increase in productive capacity and technological progress $\tau 3$.

However, as the economy approaches the mature stage, these negative effects are less effective and fertility trends are increasingly determined by the net effect of productive capacity and educational attainment (technological progress $\tau 2$). The sign of the combined effect, thus, depends on the relative weights of opposing forces.

MORTALITY Compared to those of fertility trends, the factors of mortality trends are reasonably well understood. Ruling out natural disasters, the accumulated evidence suggests that mortality level is negatively associated with per capita income, educational attainment, healthful living and working conditions, and the state of public health measures. Except for living and working conditions, which may deteriorate for a brief period in the process of rapid industrialization, all other factors move in parallel with economic development. Therefore, we may express mortality as a function of per capita income

$$D = D(gdp) \tag{26}$$

where D is the vector of age-specific death rate by sex between age x and $x + n$. The mortality elasticity of per capita income in general is highly elastic at the initial stage of development because of improvements in nutrition and health conditions brought about by increments in income. This elasticity tends to lessen as mortality declines to a certain low level.

In the developing countries the inverse relation between income and mortality represented by equation (26) was interrupted by the application of low-cost public health techniques and new drugs imported from the advanced countries at times between 1940 and 1960. The consequence was a sudden drop in mortality from about thirty or more deaths per thousand population per year to less than fifteen per thousand,

without regard to economic conditions. Therefore, the public health variable might better be treated separately in mortality functions.

NATURAL GROWTH RATE OF POPULATION Given the age-sex composition of the population at any particular time, the total number of births and deaths can be calculated by multiplying the vector of population by age into the vectors of age-specific fertility and mortality rates respectively. The crude birth and death rates and thus the rate of natural increase in that year can be obtained. These rates have the advantages of being easy to understand and to handle. One serious defect, however, is that these rates conceal the effects of the age and sex structure. Therefore it is desirable explicitly to incorporate the indexes of age-sex structure effects in the functional relationship of these rates.

As noted earlier, the vectors of fertility and mortality rates are determined by the contemporary level of economic development, i.e., the variables determining per capita output. The age composition of a closed population is the result of the trends of fertility and mortality over a long period. Therefore, age composition reflects the effects of the former variables of economic development. Accordingly, the crude birth and death rates and finally the rate of natural increase must be functions of current and earlier values of these variables. Denoting the per capita output determinants in year t as y_t, the natural growth rate of population (n) may be expressed mathematically as

$$(27) \qquad n = n(y_t, y_{t-1}, \ldots\ldots y_{t-n})$$

The relative importance of various coefficients of the variables in (27) varies because the time structure of the interaction for respective fertility and mortality rates is not the same. In a closed

population, persons at age twenty-five in year t, for example, are the survivors of the births occurring twenty-five years earlier, i.e., the product of the survival ratio from birth to twenty-five years of age and the number of births twenty-five years ago. The survival ratio, in turn, is the cumulative product of the respective product of the respective survival ratios for persons at age zero to twenty-five years old from year t - 25 to t. The latter is calculated from the mortality rate of that year and is the function of the per capita income in that year, therefore, the survival ratio from birth to twenty-five years of age is related to the per capita income for the twenty-five preceding years. Applying this relation to population for all ages it is seen that the current mortality rate (and thus the income) affects the population of persons of all ages. Mortality rates of certain past years, however, affect only the population of persons of a certain age and older. Therefore, the recent variables have great weight in determining the death rate. The relations between death rates and incomes of current and earlier years are, of course, negative.

The time structure of the weights for income in crude birth rate function is more important and complicated than that of death rate. The variable vector of the per capita output y for a particular year has an immediate effect on the fertility rate and thus the crude birth rate in that year. The number of female births in that year, however, can also influence the birth rate at least after a period of fifteen years -- when the girls will have reached the reproductive stage. The influence reflected fifteen years later increases gradually in strength, reaches its peak after about twenty-five to thirty-five years, and wanes, then vanishes in later years. This time structure

indicates that the current year and the twenty-five to thirty-five year lagged variables in the crude birth function are most relevant to the determination of today's birth rate. The direction of the effect of current income on the birth rate, as discussed above, depends on the current stage of development. The direction of a lagged development effect is determined by the stage of development. Therefore, the effect of the age structure of reproductive women implies a built-in factor that intensifies the cyclical fluctuations of the fertility rate and shifts the cycle into the next generation.

Given the size of the population in the initial year (N_o) an equation for rate of natural growth can be used to calculate the population for the current year, that is

$$(28) \qquad N_t = N_o e^{\int_o^t n(y_t \cdots y_{t-n})dt}$$

LABOR SUPPLY AND EMPLOYMENT Studies on the pattern of labor force participation rates universally show that nearly all adult males, but only part of adult women, and young and old persons, engage in or are available for income-producing activities.[11] Related to this variation in participation is a complex of inter-related demographic, social, and economic factors, some of which are common to all sections of the population and some that are especially relevant to a particular group.[12] Degree of urbanization, level of earnings, and the volume and composition of employment opportunities are generally found to be associated with both sexes at all ages. The school attendance rate has a significant effect on the activity rate of young people. Marital status and maternal responsibilities are especially important in the determination of the number of female workers. This array of factors, as diverse as they are, may be adequately represented by the vector of variables

contained in our two-sector aggregate production function (y). The degree of urbanization can be measured by the proportion of nonagricultural employment ρ_n; levels of earning and employment opportunities by the productive capacity k; school attendance rate by index of labor efficiency τ_{ln}; and marital status and maternal responsibilities by the fertility level F. As a result, we may express the age-sex specific participation rates or the gross participation rate (l) as

$$(29) \qquad l = LP/N = l(y)$$

where LP stands for the total economically active population which by definition includes: employed persons, either full or part-time workers; self-employed persons; unpaid workers; the unemployed; and persons looking for a job for the first time. N stands for the total population. In general, the gross participation rate is relatively high during the stage of agricultural development because of the predominance of household farms and enterprises. As the economy proceeds toward industrialization an initial decline sets in due to urbanization, the extension of education, the rise of organized nonagricultural employment, and the increase in womens' childcare burden. A reversal trend is likely to follow the initial decline. The release of women from household responsibilities contributes to this increasing trend. Such release occurs because of the decline in fertility, the spread of modern household appliances, and the expansion of employment opportunities for women in the service industries.

Substituting equation (28) into (29) and rearranging the terms, we obtain the functional relationship between the size of the economically active population and variables of development, that is

$$(30) \qquad LP = l(y)N_o e^{\int nt}$$

The size of the labor force available to the economy in year t sets the maximum limit of man years that may be utilized by the economy. However, this limit does not indicate how much work the members of the labor force are willing and able to do. In a given sociocultural environment the amount of work performed is determined mainly by the choice of individuals between income-producing work and leisure. Time spent on preparation for future work ability and the prevailing wage rates also affect labor supplied. With the assumption that leisure is a noninferior good and the prospect that better preparation pays off better, the economy's labor supply curve is expected to slope upward in an increasing rate as supply approaches the limit of total availability. Labor supply may thus be written as an increasing function of the wage rate and the size of the available work force. Assuming this relation to be loglinear, we have:

$$(31) \qquad LS = Uw^{\phi} LP^{\Psi}, \quad \phi>0, \quad 1\geq\Psi>0$$

where U is an arbitrary constant and the parameters ϕ and Ψ respectively represent the elasticities of labor supply with respect to an increase in the wage rate and the size of the available labor force.

On the demand side, the marginal revenue product of employed labor function (in terms of man years) derived from the two-sector aggregate production function (in sectoral equilibrium) gives the profit maximization relation between the number of employed man years and the wage rate. This equation is rearranged and presented as follows:

$$(32) \qquad LD = (\alpha\rho_a + \beta\rho_n)\ GDP/Pw$$

In equilibrium supply equals demand, LS = LD. The equilibrium solutions of wage and employment for given LP and GDP are respectively

$$(33) \qquad w_e = ((\alpha\rho_a + \beta\rho_n)GDP \quad p/\ ULP\ )^{\frac{1}{1+\phi}}$$

$$(34) \qquad LD_e = ((\alpha\rho_a + \beta\rho_n)GDP \quad P)^{\phi}\ ULP^{\psi}\ )^{\frac{1}{1+\phi}}$$

The equilibrium locus of wage rate and employed man years together with the curves of labor supply and demand at various stages of development are depicted in Figure 1. There are two significant phases for the agricultural development stage, the subsistence phase and the growth phase. In the subsistence phase the practice of primitive cultivation techniques permits only the level of output and thus of demand for labor that can absorb a relatively small portion of the available man years. The persistent insufficient demand for labor tends to encourage certain social arrangements under which the majority of the members may have opportunities to engage in economic activities. These arrangements do not necessarily provide an equal share of work for all members, namely some may be fully employed but others not. Assuming rationality, there is a tendency to employ the number of man years necessary for increase up to zero marginal revenue product, and to pay each member in accordance with his contribution (actual working time). A reduction in man years will surely raise the marginal product and cut down the total output. But withdrawal of workers may not have any adverse effect on production as long as their share of work and income can be taken over by the rest of the members in such a manner that the disutility derived from the increments of work does not exceed the utility from the increments of work.[13] Under the severe pressure of shortage in work opportunities this arrangement is most likely the case. In Figure 1, $OE_a o$ and $E_{ao}LP_a$ represent the equilibrium

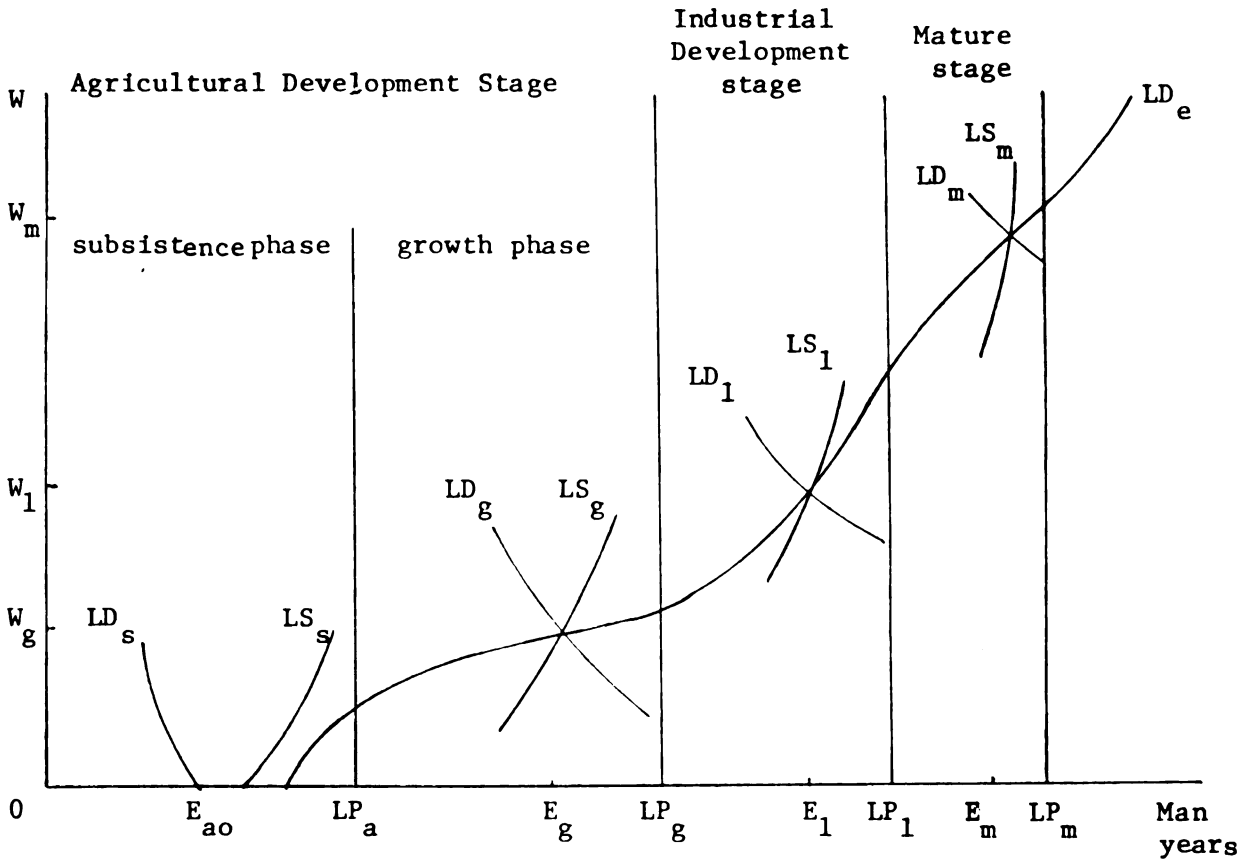

Figure 1. Labor Supply and Labor Demand at Various Stagesof Development

employed and unemployed man years respectively. There is no way to tell the actual number of persons who are fully or partly employed or unemployed from this graph. From the above argument, however, we know that the magnitude of the fully occupied workers must be somewhere to the left of E_{ao}, and from there to somewhere to the right of E_{ao} measures the number of underemployed persons. The remaining distance up to the limit of the availability, LP_{ao} measures the openly unemployed workers. The loss from vagueness in the measurements in natural units of workers is small in comparison with the advantage to be gained from an exact gauge of the extent of the employment situation as developed in terms of man years.

In the growth stage agricultural output is pushed up by the progress in techniques and can therefore support a relatively high level of demand for labor. This demand curve (as shown in Figure 1, labelled LD_g) intersects the supply curve (LS_g) in its increasing portion. Consequently, the equilibrium wage rate (w_g) becomes positive and the equilibrium employed man years (E_g) is relatively high as compared with total availability. Underemployment is not likely to be completely eliminated, because growth of the economically active population in this stage is faster than that of the demand for labor.

During the industrial development period, the growth of modern nonfarm establishments provides more and more full time jobs. At the same time the rate of increase in the economically active population tends to slow down because growth of population is moderated by a decline in the fertility rate. As a result, the underemployment situation improves.

In the mature economy stage, the normal level of demand for

labor is sufficiently high relative to supply. Therefore, the extent of underemployment is likely to be rather low, although open unemployment may still be serious because of economic maladjustment. In the most serious case, i.e., a depression, the demand curve may shift to such a low level that highly developed techniques and sophisticated capital equipment and skills are not needed. Under this circumstance, irrespective of their training and skill,the workers would be willing to perform and to share whatever work is available with others to meet the conditions prevailing in the labor market. This kind of underemployment is not different in nature from that of other stages of development. Therefore the term "disguised unemployment" (coined by Joan Robinson) for the industrialized countries is not incompatible with the one used by development economists for developing countries of today.[14]

The above discussion implies that irrespective of the stage of development the problem of under- or unemployment of labor is only a matter of degree. Sustained full employment, like the sustained growth of output, is one of the ultimate objectives of economic development. Attainment of this objective depends on the performance of the population and the economy. Our purpose is to construct an economic-demographic model to show these interactions; therefore, we shall closely follow the line of the unemployment growth model.[15]

b. Saving and Capital Formation

We now turn to an analysis of the effects of economic and demographic factors on capital formation. Capital increases by investment. The latter results from the interplay of the forces of ex ante investment and saving. Both of the forces function simultaneously in all stages of development. The shortage of capital during the earlier

period of development does not necessarily imply the existence of an investment demand which would be sufficiently high to make the desired level of saving and/or foreign assistance realizable. In fact, economic considerations (especially absorptive capacity) can support only a relatively low demand for investment. This low investment demand not only limits the realization of real saving, but also encourages unproductive consumption. Extensive hoarding of precious metals and stones, and extravagant ceremonial consumption in most of the developing countries are inevitable consequences. Due to these considerations, our model shall deviate from the neoclassical assumption that all savings are productively invested. Instead, realized investment in our model is determined simulatenously by a system of equations for supply of and demand for investment and money.

The supply for investment originates from saving. Saving may be undertaken by households, business enterprises, government, or may come from abroad. Household saving, by definition, is the amount of the surplus of personal disposable income over consumption expenditure. Both of its components are subject to the influence of fiscal and other government measures, but the main effect derives from the desire for consumption. This desire varies with a number of factors: the share and distribution of income (wLD, rK), the stock of wealth (K), and the size and composition of the population (N) are found theoretically and empirically to be the most relevant factors.[16] Business saving originates largely from the total real profit (rK). Its relative importance in the bulk of aggregate saving becomes increasingly crucial as corporate ownership spreads in the process of industrialization. Saving generated by the government is measured by an excess of revenue

over current expenditure. In the long run, taxation provides the bulk of the government revenue, and taxes are generally collected in accordance with the principle of ability to pay, i.e., income shares. Government expenditure (and therefore saving) tends to be associated with the level of development. The amount of foreign saving available to a country depends on a number of factors outside our system and is therefore treated as an exogenous variable.

Symbolically, the existing knowledge of the determinants of aggregate net saving function may be summarized as follows:

$$(35) \qquad S = S(wLK, rK, K, N)$$

Assuming this function is homogeneous to the first degree, then the net saving per employed worker is

$$(35a) \qquad s = S/LD = S(w, rk, k, N/LD)$$

Under perfect competition w and r are marginal products of labor and capital. Then we can obtain

$$(35b) \qquad s = s(k)$$

Differentiating (35a) and (35b) partially with respect to k, and using the ratio of the share of wage income (a) to the elasticity of substitution (δ) which is $a/\delta = -k(dr/dk)/\gamma$, we find

$$(36) \qquad \partial s/\partial k = \gamma(\partial s/\partial wLD\ a/\delta + \partial s/\partial rK(\ 1 - a/\delta)) + \partial S/\partial k + \partial S/\partial(N/LD)(\partial N/LD/\partial k)$$

The expression in the parentheses on the right hand side represents the marginal propensities to save when wages and profits rise and capital stock and population remain constant. In a constant return Cobb-Douglas type of world $\delta = 1, 0<a<1$, and $r>0$, therefore the sign of the marginal propensity to save out of income shares depends on $\alpha s/\alpha rK$ and $\alpha s/\alpha w$. It has long been argued, with some statistical

evidence, that owners of capital save a fixed proportion of their earnings and wage earners are devoted only to consumer expenditure, i.e., $\alpha s/\alpha rK$ = constant and $\alpha s/\alpha w = 0$.[17] Recent studies on saving behavior, especially those based on the developing countries, cast doubt on the proposition. First, if the supply of net saving is defined as wealth being diverted from immediate consumption to pay for the purchase of additional future income,one would expect that after a certain amount of saving the negative "income effect" will outweigh the positive "substitution effect" so that the propensity to save will increase with a decreasing rate at first and then decline, or even turn out to be negative as savings are accumulated.

Second, the speculation that there exists a consumption pressure on voluntary saving caused by an international demonstration effect on low income countries has not been fully supported by the empirical findings. To the contrary, evidence shows that those who spend on modern consumer objects tend to save more and to utilize modern financial facilities to make funds readily available for investment purposes. In addition, they are also shown to have modern attitudes and behavior with respect to innovative practices and family planning.[18] Spending on education, health care, and even on food is found to be attributable to the productivity of the working force and consequently to saving capacity. Judging from these findings, some of the consumption expenditures classified by the conventional definition as savings should be treated as funds directly channelled to investment flow.

Last but not least, the prevalence in the developing countries of the desire for support from one's children in one's old age perhaps reflects the fact that outlays on raising and training children, made

voluntarily or involuntarily, are still one of the best forms of saving accessible to the majority of people in such circumstances. Due to the increasingly high population pressure on land and the changes in attitude toward family relations, rewards for this kind of saving now tend to be low and risky. This form of saving is also likely to be a burden to the economy as a whole. Saving via children, however, is not different in nature from funds saved for financial markets.[19] Accordingly, expenditures on children for this purpose (mainly carried out by wage earners) should be treated as saving,too. In fact, development economists have long recognized the existence of this source of saving in terms of surplus labor. The fundamental problem, however, is not that workers do not save, but rather that their saving must be directed into more productive uses.

All of the above findings seem to support the belief that both capital owners and wage earners are willing to save part of their income, and that low income impairs ability to save efficiently, while high income may dilute saving motivations.

The second term on the right hand side of equation (36) is equivalent to the real balance effect on saving. It is known to be negative. Like the income effect, its significance would perhaps show up only after the attainment of a relatively high income level.

The last term of equation (36) represents the effect of changes in the population-employment ratio on per-worker saving. The first component of the term is the marginal propensity to save with respect to the population-employment ratio. It is negative because the larger the population relative to productive workers the heavier the burden on the ability to save. The second component is the responsiveness of

the population-employment ratio to the increase in capital stock per worker. Its sign depends on the stage of development. As noted before, in the agricultural development stage population tends to grow faster than employment and as a result it tends to be positive. This tendency reverses to negative in later stages because the growth of employment is likely to be faster than that of population. The combined effect of the two components is consequently negative in the stage of agricultural development and positive in the industrialization and mature stages. The positive effect is not unexpected, because the population-employment ratio is not the same as the dependency ratio -- the ratio of population to persons fifteen to sixty-five years of age. The latter represents the demographic effect; its effect on saving is likely to be negative throughout all stages of development.[20] The former contains both the demographic and economic effect. Therefore, the effect may be negative or positive, depending on the relative strengths of population and economic factors.

The determinants governing the demand for investment may be seen to operate on two levels. The first level consists of those determinants related to the ways in which investors make their decisions about the employment of capital equipment. The second covers those connected with absorptive capacity, i.e., the availability of the investors and complementary factors of production with which capital is to cooperate. Investment theories and their empirical verifications mainly concentrate on the explanation of the determinants at the first level, with the implicit assumption that the variables at the second level remain unchanged. On the contrary, in the economic development literature, investment demand is recognized as an effective force in

the determination of the actual magnitude of capital formation. But most of the literature concentrates on discussion of the factors at the second level and neglects those at the first. Each treatment may be appropriate to its own substance, but for a discussion of the course of economic development we should consider the variables at both levels.

According to the recent integration of the acceleration principle and neoclassical investment-demand theory, in an output market characterized by excess supply, the profit maximizing investor's decision depends upon the interest rate (q), the real wage rate, the existing capital stock, as well as on the changes in the level of output.[21] In terms of per-person employed we may have an investment function as follows:

$$(37) \qquad i = I(q, w, k, \dot{gdp})$$

where $\dot{gdp} = dgdp/dt$.

Although this is a result of rigorous logical reasoning, it deals with the factors influencing the investment decision only; those influencing the capital absorptive capacity are not explicitly expressed in the function. The important limitations to an economy's capacity to absorb capital are shortages of entrepreneurship, management, and technical skill as well as the lack of efficient public administration. As diverse as they appear to be, these complementary factors are, in fact, closely associated with the level of development. Therefore, per capita output may be used as a summary index. In addition, demographic factors are also found to have significant influence on the level and the composition of investment.[22] Taking all relevant arguments into account we may rewrite the investment function (37) as

$$(37a) \qquad i = I'(q, w, k, \dot{gdp}, gdp, N)$$

Since w, the marginal productivity of labor, gdp, and N are all functions of k, equation (37a) can be made a function of q and k.

(37b) $i = i(q, k)$

The partial derivative of (37b) with respect to q, $\alpha i/\alpha q$, is the marginal propensity to invest with respect to interest rate which is known to be negative. Differentiating (37a) and (37b) partially with respect to k we find

(38) $$\partial i/\partial k = (\partial I/\partial w)(\partial w/\partial k) + (\partial I/\partial \dot{gdp})(\partial \dot{gdp}/\partial k) + (\partial I/\partial gdp)(\partial I/\partial k) + (\partial I/\partial N)(\partial N/\partial k) + \partial I/\partial k$$

It can be seen that the marginal propensity to invest with respect to per capita capital is the sum of the effects of factor price substitution, acceleration, absorptive capacity, population, and capital accumulation. The first three are positive since the effect of changes in wage rate and in the rate of changes in response to changes in per capita capital stock are both positive. The higher the rate of population growth, the more investments are required merely to keep income per capita constant -- the so-called "demographic investment." Therefore the signs of the first components of the population effect are positive. As discussed in the previous section, except at fairly high income levels, i.e., a large magnitude of k, further increase in k might bring a decrease in population growth, so that in general the changes in population are positively related to changes in income. Therefore the population effect on investment demand with the exception of the highest extreme point is positive. The capital accumulation effect is negative, but as one would expect, it would be significant only when capital stock relative to population becomes redundant. On the whole, $\alpha i/\alpha k$ is a positive and decreasing function of per capita

capital.

Up to this point we have discussed the supply of and demand for investment in the commodity market. The final forms of the functional relationships are

(35b) $s = s(k)$

(37b) $i = i(q, k)$

The equilibrium condition in the commodity market is that saving equals investment, i.e., $s = i$. This relation allows us to solve q in terms of k; that is

(39) $q = Q(k)$

Equation (39) represents the commodity market-clearing interest rate as a function of the capital-employment ratio. It is akin to the IS curve in macroeconomic theory. The slope of the curve is $dq/dk = (\alpha i/\alpha k - \alpha s/\alpha k)/ - \alpha i/\alpha q$. Since $\alpha i/\alpha q < 1$, it is positive when $1 > \alpha i/\alpha k > \alpha s/\alpha k > 0$ and negative when $1 > \alpha s/\alpha k > \alpha i/\alpha k > 0$.

In order to obtain the equilibrium values of the capital-employment ratio and the interest rate, it is necessary to have a money market. The supply of money is assumed to be exogenously determined by the monetary authority, i.e., $MS = \bar{M}$. The demand for real cash balance (MD), in accordance with the Keynesian theory, is a decreasing function of the interest rate and an increasing function of income. Meltzer, Bronfenbrenner, and Mayer have found, however, that the variable of nonhuman wealth better explains the demand for real cash balance in the United States than does the income variable.[23] Accordingly, we may write the demand function as:

(40) $MD = pL(q, k)$

when at equilibrium $\bar{M} = pL(q, k)$. Eliminating p by substituting wage

rate equation (32) we have

$$(41) \qquad L(q, k)/\bar{M} = agdp/w$$

Rearranging terms, we can express the interest rate as a function of the capital-employment ratio and the money rate, that is

$$(42) \qquad q = q(k, w),$$

which is obviously a variant of the LM schedule. The partial derivative of q with respect to k, viz., $\alpha q/\alpha k$, is negative. This is true because for any given money wage rate, an increase in capital-employment ratio k will raise the marginal product of labor which, in turn, will lead to a lower price level to maintain equality with the real wage rate. A lower price level brings in a lower interest rate through its favorable effect on the real balance for a given supply of money. The partial derivative of q with respect to money wage rate w, viz., $\alpha q/\alpha w$, is positive because for a given magnitude of k an increase in the wage rate exerts pressure on the commodity market and thus raises the price level. A higher price level reduces the real balance and thus the interest rate increases.

Portraying equations (39) and (42) in the conventional Hicksian version in quadrant I of Figure 2 we have, respectively, the loci of interest rate and capital-employment ratio at which planned saving equals planned accumulation (investment) in the commodity market and money supply equals money demand for given wage rate w in the loan market. Their intersection, the solution of equations (39) and (42), is at k_o and q_o which corresponds to a "warranted growth" equilibrium for a given money wage rate.

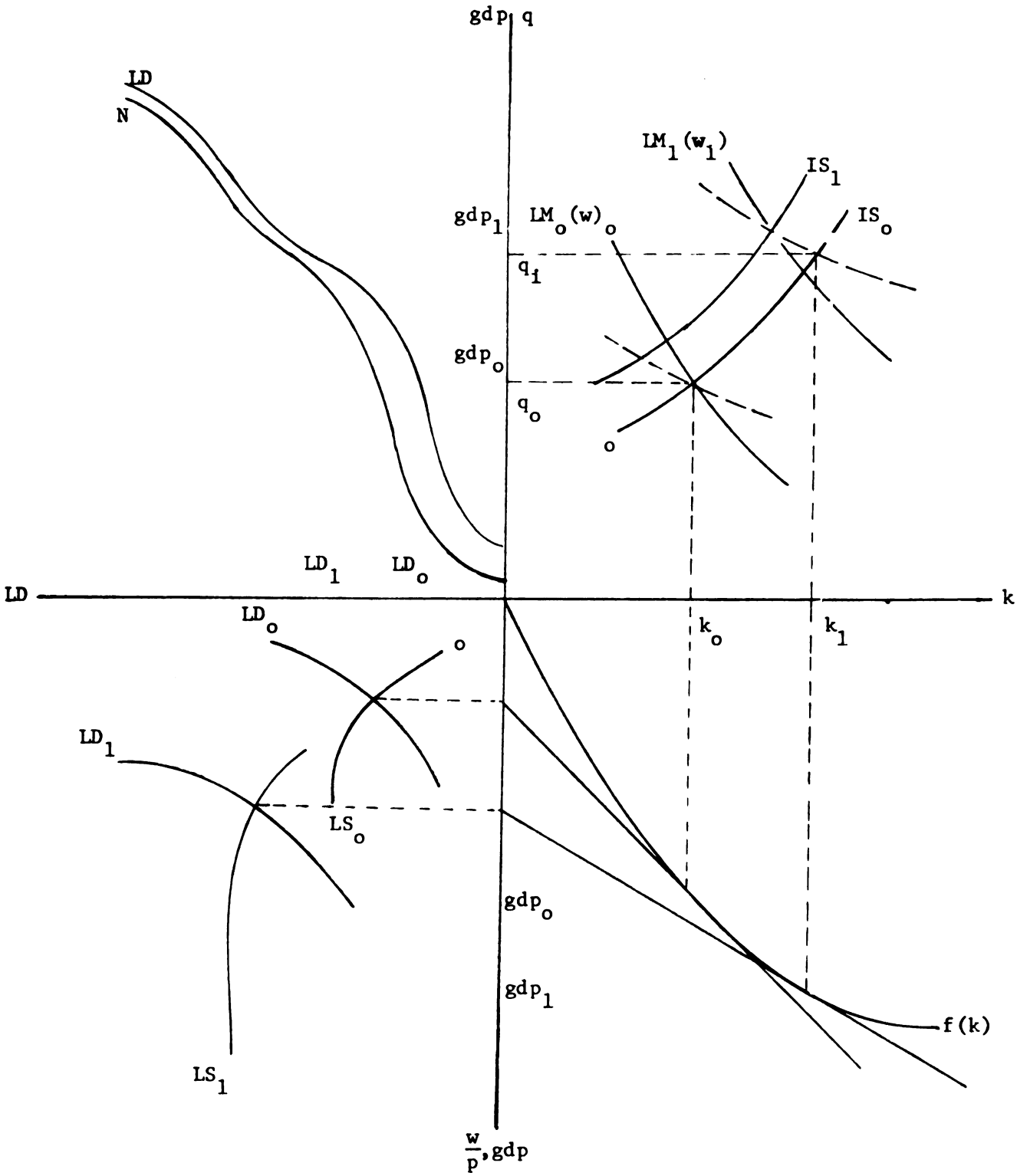

Figure 2. Graphical Presentation of Economic-Demographic Equilibrium

c. The Workings of the Short-Run Market Equilibrium

In the preceding two sections we have examined the relation of economic development to the size and composition of population; population effects on the supply of and demand for labor and capital accumulation; and then the equilibrium conditions of the labor, capital, and money markets. On one side, the growth of population is mainly a consequence of economic development and on the other it plays a crucial role in the development of the economy; it provides the human resources and incentives to invest and also diverts saving from material capital accumulation to human investment. In this section we attempt to put all these unidirectional relationships together to examine their mutual interactions.

We have previously developed a two-sector aggregate production function and individual equations for demand and supply, and for labor, commodity (capital), and money markets. These equations plus the definitional relationships permit us to solve for all the endogenous variables. For the purpose of showing explicitly the relationship between employment and capital accumulation in our model it is best to specify the formal mathematical terms as follows:

$GDP = F(K, LD)$	production
$k = K/LD$	capital-employment ratio
$s(k, q) = i(k, q)$	commodity market
$L(k, q) = \bar{M}/p$	money market
$F_{LD}(K, LD) = w/p$	labor demand
$N(GDP, LD) = w/p$	labor supply

The system, which contains six equations representing six endogenous variables (Y, K, LD, k, q, and p) and two exogenous variables

($\bar{M}$ and w), is indecomposable; thus the equilibriums of the endogenous variables are simultaneously determined. Incorporating the shift parameters in each of the equations and totally differentiating the equations we can solve the system for each of the endogenous variables (dGDP, dK, dLD, dk, dq, and dp) in terms of the exogenous variables and then compute the multipliers. These results are precise but they are rather cumbersome.

Utilizing the properties of the first degree homogneity of the production function and by substitution, as we have done earlier, we transformed our system as follows:

$s(k) = i(k, q)$	commodity
$L(k, q) = (gdp - kf')\bar{M}/w$	money market
$gdp - kf' = w/p = N(GDP, LS)$	labor market
$gdp = f(k)$	production

This simplified version can be illustrated in a four-quadrant diagram to show the workings of the model in a more comprehensible manner. In quadrant I of Figure 2 we have the set of IS and LM curves. In quadrant II the aggregate production function is plotted. The intercept on Ogdp of the tangent to the production curve gives the real wage rate. Quadrant III presents the labor supply and demand curves, and quadrant IV presents the growth of employment, labor availability, and production.

The system will gravitate to the equilibrium for a given money wage rate and stock of money. This can be seen by considering an autonomous rise of the propensity to invest or a fall of propensity to save. Either change pushes the IS curve upwards. The excess demand

for goods raises prices and thereby the money wage rate. A higher money wage rate shifts the LM curve to the left, which brings the equilibrium interest rate and equilibrium capital-employment ratio from q_o and k_o to q_1 and k_1. The new equilibrium capital-employment ratio k_1 gives a larger value of wage-rental ratio, h_1, which, in turn, yields a larger equilibrium value of output per worker, gdp_1. An instantaneous response to the increase in output per worker is a rise of the demand for and supply of labor and thus a higher employment LD_1. The amount of employment, however, is limited by the availability of labor, which again is limited by the size of the population. In the long run this bottleneck will be broken either by the growth of the population or by technological progress.

4. Interactions between Population Growth and Economic Development

In the course of our discussion thus far we have developed an economic-demographic model with two kinds of equilibria: market and sectoral. In addition to the features of the short-run Keynesian model the workings of the market take one more factor into account -- endogenous capital accumulation. The commodity and money market equilibria are not prerequisites for a sectoral equilibrium, for any equilibrium value of k gives a value of h which governs the allocation of resources and brings the system towards a sectoral equilibrium. Thus it is expected that the sectoral adjustments take longer to attain an equilibrium than do the commodity and money markets. Therefore, the former may be regarded as an intermediate run analysis and the latter as a short run analysis. The attainment of the two equilibria, however, does not

deal directly with the effects of the size and composition of the population and technological progress in the determination of the warranted rate of accumulation. To incorporate these additional factors into the system, we are led to an analysis of the long-run steady-state growth. A steady-state growth requires equilibria in both markets and sectors. Disturbances of long-run growth can therefore arise either from the long-run side or from the determinants of sectoral and market equilibria.

It was noted that for a given money supply, money wage rate, and employment rate, market forces determine an equilibrium ratio of capital stock to employment. The clearance of the labor market, however, is in the sense of hiring the number of man years at which the firms' profits will be maximized, which need not mean the attainment of full employment. The equilibrium capital-employment ratio, therefore, differs from the ratio of capital stock to the total available labor force. Denoting the latter (capital-labor force ratio) as v we have

$$(43) \qquad v = K/LP$$

The employment rate is the ratio of employment to the availability of labor, $u = LD/LP$, then by definition of k and v we get

$$(44) \qquad u = LD/LP = v/k$$

The growth rate of the capital-labor ratio, by (43), is the difference between the growth rate of capital accumulation and that of the labor force, i.e., $\hat{v} = \hat{K} - \hat{LP} = i(k, q)LD/K - (\hat{1} + n)$. Assuming that investment demand is independently determined, then by substituting equations (37b), (30), and (44) in the growth equality we obtain

(45) $\dot{v} = u(i (k, q) - k(\hat{l} + n))$

If again we assume that full employment is perpetually maintained, ex ante saving equals ex ante investment, and the participation rate of labor is constant, so that $k = v$, $u = \hat{l}$, and $l = 0$, then equation (45) turns out to be the Solow growth model, namely

(45a) $\dot{k} = s(k) - kn$

Our model, however, does not rely on any of these assumptions. First of all, the investment demand function is a structural relationship. The actual amount of capital accumulation and the capital-employment ratio emerge from a general equilibrium solution in which the aggregate supply of and demand for output, money, and employment are all equated simultaneously. We insert these market solutions into (44) and after some manipulation the differential equation (45) for the capital-labor ratio becomes

(46) $\dot{v} = u ((1 + b) \dot{k} + k(\phi (\hat{a} + \tau) - (1 - \psi)(\hat{l} + n))$

where $a = \alpha\rho_a + \beta\rho_n$ and $b = 1 - a$.

The long-run equilibrium, if it exists, is the steady-state solution of (46). It is therefore the solution to

(47) $\hat{l} + n = ((1 + b)/(1 - \psi))\hat{k} + (\phi/(1 - \psi))(\hat{a} + \tau)$

It is seen that the long-run equilibrium capital-employment ratio is at the point at which the "natural" growth rates of population and labor force equal the warranted rate of capital accumulation adjusted for the supply elasticities of labor with respect to the real wage rate (ϕ), to the total size of the working population (ψ), to the level and changes in economic structure (a, b), and to the technical progress rate (τ).

In the differential equation (46) all variables are functions

of k. Therefore the natural and the adjusted warranted rates may be plotted against k to obtain a diagram similar to the well-known Malthusian trap model developed by Nelson and Leibenstein (see Figure 3).[24]

With all other determinants specified in functions for fertility, mortality, and participation rate, namely equations (24), (26), and (29), remaining constant, with an increase in k from a very low level to a level corresponding to the subsistence level S, the natural rate curve NN will increase rapidly from negative to zero mainly due to falling mortality. As k moves to the right of S, the NN curve continues to rise at a rather fast rate until fertility and mortality reach the upper and lower physical limits respectively. Before these limits are reached, the participation rate is likely to rise from the bondage of low economic activity characterized by insufficiency of effective demand. However, the rise of the NN curve will gradually taper off as k reaches a very high level for the participation rate -- especially because participation of the female labor force will also approach the conventional limit.

Similarly the adjusted warranted rate curve GG will also increase as k increases. The GG curve, however, is likely to be S-shaped. It tends to be higher relative to the NN curve when k is below and around the neighborhood of S, a point equivalent to the subsistence level. As k moves beyond S the growth of the GG curve is generally lower than NN at first and then after a certain point outstrips NN and finally reverses the trend at the high end. The main reason for this change is that the structural effect on the efficiency of capital utilization varies with the average amount of capital stock per worker.

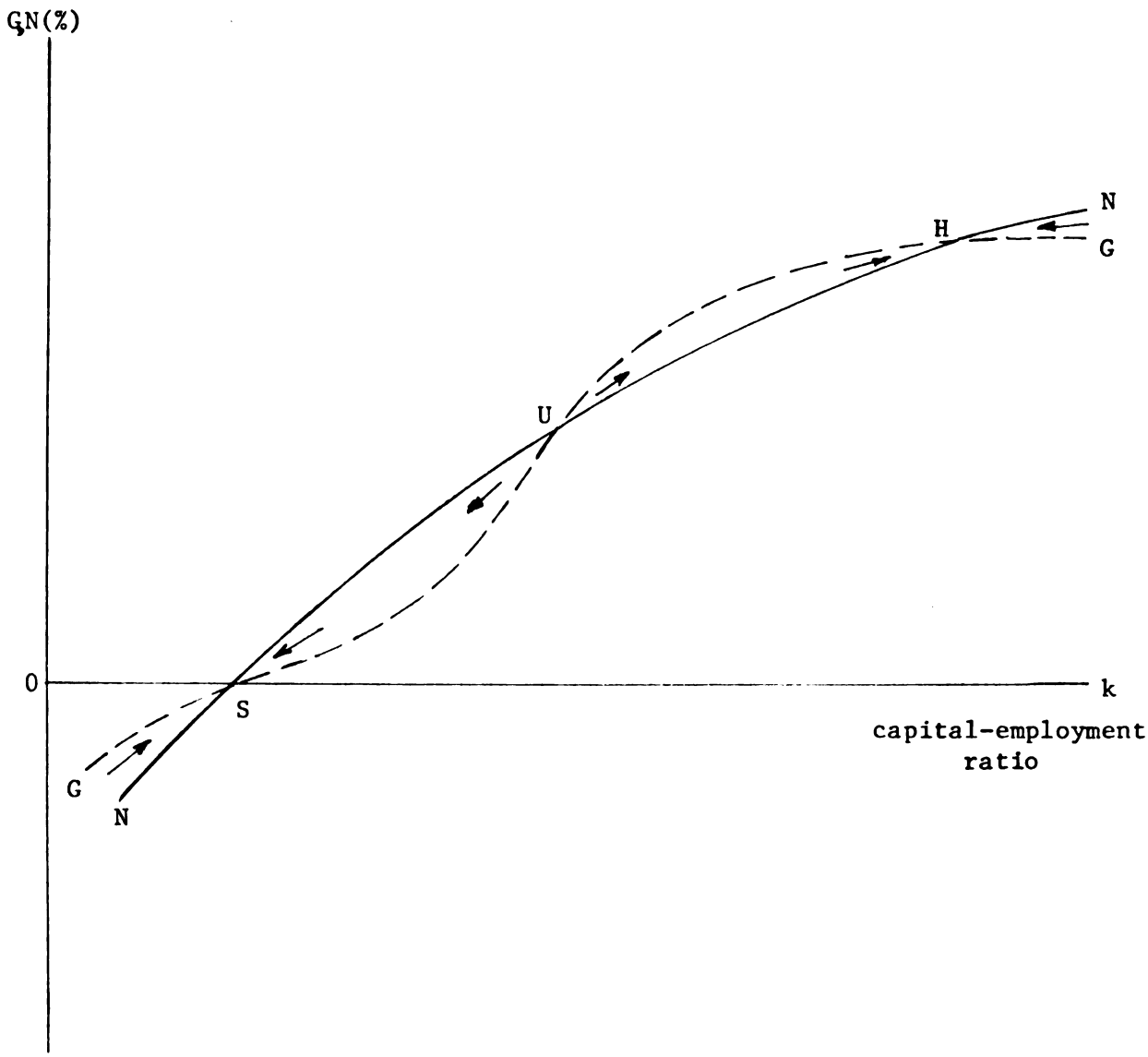

Figure 3. Natural Growth Rate of Population and Labor Force and Warranted Rate of Capital Accumulation

When capital is scarce,an increase in investment is most likely to be directed to the development of agriculture because of the lack of the complementary factors in other industries. The gains in scale economics and in population-induced technological improvements in agriculture at this stage tend to surpass the rates of population and labor force growth.[25] Yet these gains will soon be exhausted as the law of diminishing returns becomes effective. This situation might change only after sufficient capital has been accumulated in the industrial sector. At very high levels of k, the negative income effect of goods for future consumption is likely to work against the rate of capital accumulation.

The graph in Figure 3 shows that point S on the k axis represents the "low-level equilibrium trap," point U is an unstable equilibrium, and point H is a high-level equilibrium. The movements along the NN and GG curves are not hampered by the ratchet effect.[26] In our model, k represents the productive capacity of the economy only, and the effects of other variables accompanying the economic development have been isolated. Hence, there is no ratchet effect. The changes in the latter variables will induce shifts in the positions of the NN and GG curves.

As noted earlier, the interactions of changes in the variables of our system differ in strength and direction at various stages of development. A deliberate impetus, small or large, on a certain selected set of variables would thus produce a more influential force to bring the economy toward a higher level of equilibrium than would other selected sets. A critical minimum effort is not implied by our model to be a necessary condition for rescuing the low income countries from

the Malthusian trap.

It should be noted that the growth of capital accumulation per employed worker is jointly determined by supply of and demand for investment, labor force, and capital in the short run. Therefore, our model does not offer a direct comparison of the growth rates of population and labor force with capital accumulation. The rates of population and labor force growth have been explored to their sources: fertility, mortality, migration (allocation of labor force), and participation, and they are part of the system. Factors affecting the rate and efficiency of capital utilization are also incorporated. As a result, our model gets us a step closer to an explanation of "the variety of individual and institutional adjustments to problems of economic growth."[27]

5. Concluding Remarks

The economic-demographic model constructed in the present chapter is characterized by several features pertinent to the problems of the developing countries. First, the distinction of the conceptual time horizons, viz., short, intermediate, and long run, provides a configuration for cataloging the intricate economic-demographic relationships in proper places. Next, the model takes structural shifts and changes in economic activities, income distribution, consumption, and investment patterns into consideration. Third, the full employment of labor is not assumed in the model; therefore, the problems of under- and unemployment can be analyzed in our growth model. Finally, the equality of saving and investment is not taken for granted; one of the bottlenecks of development, i.e., absorptive capacity, has been incorporated

in the model.

One main shortcoming of the model is that it is less than realistic because of the lack of a foreign market. In fact, this defect can be remedied by adding an input in the production functions and import and export relationships on the aggregate demand side.[28] The inclusion of a foreign market makes the model more complicated, but the basic results of the original model are not changed. The second main shortcoming is that the money wage rate and relative prices are not endogenously determined in the system. It is possible to introduce a set of functional relations between money wage (prices) and wage (prices) determinants to complete the system. Since the inclusion of wage and price determinants will not affect the basic nature of the model we purposely left them out.

On balance we have confidence that our model should be adequate for use as a framework to evaluate statistically the interactions between population changes and economic development. Moreover, our model should be helpful in pinpointing relationships pertaining to a particular developmental stage.

Footnotes

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CHAPTER III. ECONOMIC DEVELOPMENT AND POPULATION IN TAIWAN SINCE 1895: AN OVERVIEW

The history of economic development and population growth in Taiwan since the turn of the century is characterized by a transition from a traditional to a modern industrial society. There are different interpretations as to the immediate causes of this transition. The basic underlying factors, however, may be the level and pattern of aggregate demand. As the level and pattern of aggregate demand change, the extent and structure of economic activities adjust accordingly. These responses affect the social and economic characteristics of the population which in turn influence the growth and distribution of the population. Again, the changes in size and characteristics of the population affect the level and pattern of demand. The last causal relation has been demonstrated by the recent experience of the developing countries. Most of the economist's concerns are thus focused on this relation. Studies that trace the relation back to aggregate demand are rare. The long-run historical evidence in Taiwan, however, shows that the level and pattern of aggregate demand have played a curcial role in the course of economic and population growth. This may be due largely to Taiwan being a small island and having to rely on the international market for its development. To be more specific, Taiwan is a mountainous island of only 13,885 square miles. The economic value of its mineral deposits is negligible.

Arable land is ranked as the best endowment on the island. However, it consists of only one-fourth of the total area. Furthermore, the quality of the arable land is poor, and the rainfall is unevenly distributed throughout the year. Because of the absence of natural wealth, the development of Taiwan has to depend on the mobilization of human resources and on the accumulation of material capital. The extent and methods of mobilization and accumulation are closely associated with changes in aggregate demand. Since domestic demand is limited by the size of the domestic market, international demand inevitably plays an important role. International demand is primarily subject to changes in external conditions and domestic demand is influenced by the stages of socioeconomic development and government policies.

Taiwan's economy has experienced two distinct patterns of aggregate demand, one traditional, the other developmental. The traditional type is characterized by agriculturally oriented demand. This traditional pattern occurred during the Japanese occupation period (from 1895 to 1945). The developmental pattern of demand may be further divided into two stages: labor-intensive, and skill- and/or capital-intensive. Both are guided by the forces of the free market. Taiwan has experienced a labor-intensive type of development in the past twenty years. It is expected that the skill- and/or capital-intensive type will predominate in the near future. This Chapter discusses the historical development of the two types of aggregate demand; their effects on economic activities and thus on population characteristics, growth, and distribution; and the respective feedback of each on the others.

1. The Colonial Period: 1895-1945

When Japan took over Taiwan from the Manchu government in 1895 Japanese authorities decided to develop Taiwan as a supplier of agricultural products for her industrial development. Not until the Japanese empire began to prepare for war in the middle of the 1930s was Taiwan's economic role changed to that of a supplier of industrial goods as well.

This policy is reflected in records of exports and imports. Statistics on external trade compiled by the Japanese reveal that during the colonial period most of Taiwan's trade (85 percent of Taiwan's exports and 75 percent of her imports) was with Japan and her overseas possessions. As shown in the upper panel of Table 3.1, of the total value of exports to Japan proper the share of agricultural and processed agricultural products amounted to 70 to 95 percent. Except for the first decade of occupation only 55 to 90 percent of the claims for exports to Japan was paid back to Taiwan in the form of commodities (see the upper panel of Table 3.2). Only one-third to two-fifths of imported commodities were industrial consumption goods; the remainder were mainly used as a means of producing agricultural surplus. For instance, the bulk of the imported raw materials was chemical fertilizer, which was distributed by government agents to farmers in exchange for agricultural products at an extortionate rate. The imported capital goods were mostly transportation and communication equipment which was used to facilitate the movement of raw materials and products within the island.

Until the period of Japanese preparation for the Pacific war, the pattern of exports and imports changed only slightly. Imports of capital goods, mainly plant equipment, increased at an average growth

TABLE 3.1 RELATIVE CHANGES IN TAIWAN'S EXPORTS, 1899 to 1970

Period	Value[1]	Percentage Share			Annual Rate of Growth			
		Crude Agricultural Products	Processed Agricultural Products	Manufacturers	Total Exports	Crude Agricultural Products	Processed Agricultural Products	Manufacturers
Traditional Period[2]								
1899-1904	6,978	27.5	40.7	31.8	-	-	-	-
1905-1909	21,827	34.5	56.1	9.4	38.7	53.2	60.3	1.5
1910-1914	46,436	20.8	65.3	13.4	22.6	5.7	29.1	43.2
1915-1919	98,157	19.4	64.4	16.2	22.3	19.4	21.7	29.3
1920-1924	162,949	15.0	73.5	11.5	13.2	5.7	17.9	3.6
1925-1929	213,633	33.3	62.0	4.7	6.2	39.1	2.1	9.1
1930-1934	230,249	31.3	63.0	5.7	1.6	0.3	1.9	5.7
1935-1939	402,640	29.4	53.7	16.9	15.0	12.8	9.8	84.4
1940-1943	387,786	28.3	52.4	19.3	0.9	1.8	1.5	2.6
Developmental Period								
1952-1954	115,692	18.4	75.1	6.6	-	-	-	-
1955-1959	152,240	21.6	64.7	13.6	7.9	13.8	3.4	43.0
1960-1964	293,967	13.4	43.1	43.5	18.6	3.9	5.7	103.2
1965-1969	741,508	15.7	21.8	62.5	30.5	39.3	5.5	32.1
1970	1,561,652	9.1	12.7	78.2	36.9	7.5	7.5	54.5

[1]Yearly average for each period; thousands of yen for traditional period; thousands of U.S. dollars for developmental period.

[2]Exports to Japan only.

SOURCES: Data for traditional period compiled from Taiwan Provincial Department of Statistics, Statistical Summary of Taiwan for the Past 51 Years, Department of Statistics, Taipei, 1947. Data for developmental period compiled from Council for International Economic Cooperation and Development (CIECD), Taiwan Statistical Data Book, Taipei, 1971.

TABLE 3.2 RELATIVE CHANGES IN TAIWAN'S IMPORTS, 1899 to 1970

Period	Value[1]	Ratios of Exports to Imports	Percentage Share			Annual Rate of Growth			
			Capital Goods	Raw materials	Consumption Goods	Total Imports	Capital Goods	Raw materials	Consumption Goods
Traditional Period[2]									
1899-1904	9,303	1.33	8.1	54.0	37.9	-	-	-	-
1905-1909	18,760	0.86	15.2	42.7	42.1	18.5	32.4	10.8	22.5
1910-1914	37,774	0.81	16.7	38.2	45.1	20.3	24.2	16.0	23.2
1915-1919	63,849	0.65	15.4	46.0	38.6	13.8	11.0	20.7	9.0
1920-1924	89,077	0.55	15.8	44.5	39.7	7.9	8.7	7.0	9.0
1925-1929	129,021	0.60	15.5	38.9	45.7	9.0	8.3	5.3	13.4
1930-1934	139,650	0.61	18.0	40.9	41.1	1.7	5.2	2.8	0.5
1935-1939	285,084	0.71	20.8	45.0	34.2	20.8	27.2	24.9	14.0
1940-1943	356,785	0.92	20.1	45.4	34.5	5.0	4.1	5.3	5.3
Developmental Period									
1952-1954	200,518	1.73	16.5	70.7	12.8	-	-	-	-
1955-1959	229,532	1.51	25.6	65.6	8.8	3.6	19.2	1.6	5.1
1960-1964	330,199	1.12	26.1	63.9	10.0	8.8	9.4	8.0	12.4
1965-1969	846,918	1.14	32.9	59.9	7.2	31.3	44.5	28.1	17.1
1970	1,527,697	0.98	33.8	59.5	6.7	26.8	28.5	26.4	22.6

[1]Yearly average for each period; thousands of yen for traditional period; thousands of U.S. dollars for developmental period.

[2]Imports from Japan only.

SOURCES: The same as for Table 3.1.

rate of 27 percent per year and exports of industrial goods increased at 84 percent for the period from 1935 to 1939. Even during the subsequent war period exports of industrial goods still kept on growing at 3 percent per year. Exports of agricultural products decreased to about 2 percent per year because of heavy typhoon damage.

Japan's immediate actions were making choices about the ways of organizing and mobilizing resources. By 1895 Taiwan's economy was already deep-rooted in small-scale cultivation. Every farm was made up of a household closely tied with ancestral clan affiliations. About two-thirds of the farms were operated with land rented from absentee landlords. The landed gentry were influential in local affairs, and in general they served as intermediaries between the government and the masses. This form of village organization was self-contained, self-sufficient, and resistant to external interference. It is impossible to change this kind of system without the risk of great disturbances. Since maintaining social order is one of the most important preconditions for the efficient use of resources, Japanese authorities were constrained to keep the existing agrarian system as intact as possible. Indeed, witness the fact that the size of farms, whether measured by the number of farm workers, the cultivated land acreage, or the amount of fixed capital used and the tenancy relationships, had remained unchanged during the entire colonial period (see Table 3.3).

Under these rigid traditional arrangements the authorities had to confine their efforts to promote agricultural production to the manipulation of the quantity and quality of the farms. In order to reap the highest possible surplus for Japan, special measures were also devised on the production side. The whole scheme had profound effects on the economy as well as on the population. Many of the

TABLE 3.3 NUMBER OF HOUSEHOLD FARMS, THEIR MEAN SIZE AND TENANCY RELATIONSHIPS

Period	Household Farms		Average per Farm of:				Percentage of Cultivators Who are full Owners of Land
	Number	Annual Increase Rate %	House-hold Members	Farm Workers	Cultivated Land Area (ha)	Fixed Capital (H. P.)	
Traditional Period							
1905	359,636	-	5.5	3.1	1.7	0.47	-
1909	364,282	0.32	5.4	3.0	1.8	0.63	33.7
1916	407,755	1.70	5.6	3.0	1.8	0.47	31.7
1922	385,277	0.92	5.8	2.9	1.9	0.53	31.4
1925	393,777	0.72	5.9	3.0	2.0	0.49	29.9
1930	411,377	0.89	6.2	2.9	2.0	0.50	29.3
1935	419,865	0.39	6.6	3.1	2.2	0.47	31.6
1940	429,939	0.48	6.9	3.2	2.2	0.35	31.1
Developmental Period							
1950	638,062	4.84	6.3	2.8	1.4		33.9
1955	732,555	2.96	6.3	2.5	1.2		58.8
1960	785,592	1.45	6.8	2.4	1.1		64.4
1965	847,242	1.57	6.8	2.4	1.2		66.9
1970	880,274	0.78	6.8	2.6	1.0		77.4

SOURCES: Data for traditional period from Statistical Summary of Taiwan for the Past 51 Years. Data for developmental period from Taiwan Provincial Department of Agriculture and Forestry, Taiwan Agricultural Yearbook, Taipei, 1971.

studies of the agricultural development of Taiwan, however, abstract from this framework and deal only with the aggregates of agricultural inputs and outputs. As might be expected, they all come to the conclusion that farm workers, cultivated land acreage, fixed capital, irrigated land area, crop area, chemical fertilizers used, and rural education were the most important factors in determining Taiwan's agricultural production.[1] These findings deal only with the basic technical input-output relationship of Taiwan's agricultural production. Thus they may serve as a departure for an investigation of the impact of socioeconomic factors on economy and population.

When we look at the input-output relation in terms of each farm instead of at the aggregate amounts as the previous studies did, among the above-mentioned factors only the innovative factors -- irrigated land area, crop area, amount of chemical fertilizers used, and government expenditures on rural education per farm -- increased, while the scale factors -- number of workers, cultivated land acreage, and amount of fixed capital of each farm -- were not significantly changed over the colonial period (see Tables 3.3 and 3.4). This evidence indicates that the increase in agricultural production during this period was partly due to the rise in productivity of each farm, but was mainly due to the increase in the number of farms. In other words, as the type of organization, i.e., the small-scale cultivation system, is taken into consideration, the statistics of Taiwan indicate that there were two kinds of factors of production: the scale factors, which exerted a duplication effect on agricultural production and the innovative factors, which were characterized by a productivity effect.

TABLE 3.4 AGRICULTURAL OUTPUTS AND INPUTS

Year	Agricultural Output Index	Agricultural Output per Farm Index	Irrigated Area per Farm (ha.)	Crop Area per Farm (ha.)	Chemical Fertilizer Used per Farm (M/T)
Traditional Period					
1905	100.0	100.0	0.5	1.9	0.04
1909	109.3	107.9	0.6	2.0	0.2
1916	122.5	118.5	0.6	2.0	0.3
1922	124.4	116.1	0.8	2.3	0.3
1925	176.7	161.4	0.9	2.3	0.5
1930	205.6	179.7	1.1	2.4	0.6
1935	253.8	217.5	1.1	2.6	1.0
1940	243.3	203.6	1.2	2.6	1.3
Developmental Period					
1950	254.7	143.6		2.3	0.7
1955	322.7	158.4		2.0	0.8
1960	402.8	184.4	0.7	2.0	0.8
1965	537.2	228.0	0.6	2.0	0.9
1970	666.2	272.0	0.6	1.9	1.1

SOURCES: The same as for Table 3.3.

The major concern of the colonial rulers was to maximize agricultural surplus rather than to improve the welfare of the indigenous population. The population was the source of the labor supply and labor was virtually nonsubstitutable under the rigid social customs of that period. Therefore the population of Taiwan was treated more or less like other material factors in accordance with the principle of profit maximization, i.e., population should be maintained and reproduced at the least cost, on the one hand, and should be trained to the extent that would provide the highest efficiency in agricultural production, on the other.

With respect to minimizing costs, measures were implemented to prevent the income of the population at large from rising as rapidly as productivity. The indigenous population was restricted to engaging in low-income traditional economic activities, i.e., agriculture and commerce. The large and profitable enterprises in the fields of foreign trade, transportation, sugar, camphor, tobacco, and wine were all owned and operated by the colonial government and a few Japanese.

The government also initiated large investments in technical improvements of transportation, the irrigation system, the use of chemical fertilizers, the introduction of suitable varieties of seed, and crop rotation systems. Benefits from these improvements, however, were taken back in the form of direct charge -- heavy taxation and land rent payment (see Table 3.5). What was left for the farmers was a moderate increase in income which was partly used to raise the level of consumption but was mainly saved for repayment of debts or for purchase of land assets. It may be seen from Table 3.6 that the increase in consumption expenditure of the farms from 1911 to 1940 was

TABLE 3.5 PERCENTAGE DISTRIBUTION OF NET FARM INCOME OF TAIWAN

Periods	Total Net Farm Income	Cultivators	Landlords & Money Lenders	Government & Other Public Institutions
Traditional Period				
1911-1915	100.0	65.9	26.6	7.4
1916-1920	100.0	66.2	28.0	5.8
1921-1925	100.0	65.6	26.6	7.1
1926-1930	100.0	66.5	26.4	7.7
1931-1935	100.0	66.9	25.4	7.7
1936-1940	100.0	67.1	25.2	-
Developmental Period				
1950-1955	100.0	71.2	9.8	13.1
1956-1960	100.0	81.4	6.3	12.3

SOURCE: Teng-Hui, Lee, "Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960) (unpublished Ph. D. dissertation, Cornell University, 1968), p. 205.

TABLE 3.6 AGRICULTURAL PRODUCTION PER FARMER, PER CAPITA FARM INCOME, CONSUMPTION, AND SAVINGS IN 1935-1937 NT$

Year	Agricultural Production per Farmer	Per Capita		
		Farm Income	Consumption	Savings
Traditional Period				
1911	156	48.5	45.9	2.6
1915	148	46.2	43.9	2.3
1920	172	49.9	47.0	2.9
1925	238	71.7	63.4	8.3
1930	258	71.6	66.5	5.1
1935	289	82.4	74.7	7.7
1940	290	81.3	71.3	10.0
Developmental Period				
1950	278	87.2	74.7	12.5
1955	327	89.8	65.8	24.0
1960	385	94.6	71.6	23.0

SOURCE: The same as for Table 3.5, p. 20.

relatively small in comparison with that of farm productivity and income. A study of farmers' living expenses in the last decade of the colonial period (Table 3.7) shows that more than half of the expenditure was for food. Rice and sweet potato took the lion's share of food consumption. Beverages, tobacco, and clothing accounted for about 10 percent of total expenditures, but those manufactured items were mainly supplied by enterprises either owned by the government or located in Japan proper. Furthermore, the above-mentioned investments were primarily carried out through the use of a mass labor force with a few materials and equipment imported from Japan. For instance, transportation equipment, chemical fertilizers, and cement were nearly all imported from Japan. Consequently aggregate consumption and investment demand for the Taiwanese economy were mainly concentrated on the primary industries.

The pattern of domestic demand reinforced the need for Taiwan's economy to produce more agricultural goods, and therefore induced more of the Taiwanese population to participate in primary activities. This is seen from the fact that not until the Japanese engaged in war preparations were about two-thirds of the male and four-fifths of the female labor force directly employed in agriculture. The rest of the work force was mainly used to complement these activities (see Table 3.8).

At the time Japan took over Taiwan the need for a labor force to reclaim the tillable land and to improve the newly cultivated land was much greater than the population could supply. Since the Japanese farmers migrating to Taiwan were not successful, the natural increase of population was the only feasible way to meet the high

TABLE 3.7 COMPOSITION OF FARM FAMILY EXPENDITURES

Period	Expenditures Per Farm Family (1937 prices)	Percentage of Expenditures					
		Food		Beverages and Tobacco	Clothing	Shelter	Services
		Total	% Rice & Sweet Potato in Food				
1931-1932	805	50.8	56.4	5.2	4.4	9.6	30.0
1936-1937	935	51.4	64.9	5.0	6.1	9.0	28.5
1941-1942	911	49.7	57.9	5.3	11.1	7.0	26.9

SOURCE: Han-Yu Chang, "The Livelihood of Peasant Farmers in Taiwan, Mainly Seen from the Reports of Family Budget Surveys Concerned," Journal of Social Science, Vol. 6, May 1955, College of Law, National Taiwan University, Taipei, pp. 185-228.

TABLE 3.8 OCCUPIED POPULATION AND MAJOR INDUSTRIAL COMPOSITION

Year	Occupied Population		Percentage		
	Number (1,000)	Annual Rate of Growth	Agriculture	Industry	Services
			Male		
1905	1,090	-	70.0	6.6	23.4
1915	1,165	1.4	69.2	8.6	22.2
1920	1,181	1.4	66.9	10.7	22.4
1930	1,372	1.6	66.2	10.6	23.2
1940	1,608	1.7	59.3	13.4	27.3
1950	2,085	3.0	59.3	9.0	31.1
1955	2,346	2.5	54.9	11.1	34.0
1960	2,622	2.4	51.1	12.7	36.2
1965	2,961	2.6	49.1	13.4	37.5
1970	3,809	5.7	39.8	16.0	44.2
			Female		
1905	314	-	83.8	5.9	10.3
1915	478	10.4	82.0	9.7	8.3
1920	456	0.9	82.8	8.3	8.9
1930	418	0.8	80.0	7.5	12.5
1940	635	5.2	75.7	7.7	16.6
1950	764	2.0	72.3	3.0	24.7
1955	680	2.2	77.1	5.1	17.8
1960	720	1.2	74.6	6.0	19.4
1965	794	2.1	71.0	6.5	22.5
1970	1,244	11.3	58.3	15.2	26.5

SOURCES: Data for 1905 to 1940 from Population Census Reports for the respective years. Data for 1950 to 1970 from Population Registration Reports for the respective years.

demand for labor. In an agriculturally oriented economy like Taiwan's, fertility had always attained the highest reproductive capacity through the mechanism of institutional forces. The only alternative left for raising the rate of natural increase was to lower mortality. This was achieved by relying more on administrative devices than on government spending on health programs.[2] By 1920 epidemics (mainly plague and cholera) were brought under control, which cost only about NT$ 7 per capita per year at 1952-1956 prices, equivalent to 30 cents in US$). In later years, efforts were directed to installing medical facilities and training health personnel. However, the health expenditures per person rarely exceeded NT$ 24 (US$ 1.00). As a result, the death rate dropped rapidly without interruption from 33 deaths per 1000 population in the period from 1905 to 1909, to 19 per 1000 in the period from 1940 to 1943 (see Table 3.9). Due to better health conditions there were also some favorable effects on the birth rate, which increased slightly from 40 births per 1000 population in the period from 1905 to 1909, to 45 per 1000 for 1930 to 1939. Consequently the rate of natural increase rose from 7 per 1000 population to 26 per 1000 during the same years.

The increasingly high rate of natural growth doubled the Taiwanese population from 3 million in 1905 to 6 million in 1943. The labor force, however, did not keep pace with population growth. This phenomenon was primarily attributable to the juvenilization of population resulting from the increase in fertility and the reduction in mortality, and to changes in the participation rate of the labor force. Socioeconomic development brought a slight decline in the participation rate of active males, but the improvement of health conditions

TABLE 3.9 BIRTH RATES, DEATH RATES, AND RATES OF NATURAL INCREASE, TAIWAN 1906-1970

Period	Birth Rates	Death Rates	Rate of Natural Increase
Traditional Period			
1906-1909	40.3	33.3	7.0
1910-1914	42.5	27.2	15.3
1915-1919	40.4	30.8	9.6
1920-1924	41.9	26.3	15.6
1925-1929	44.1	23.1	21.0
1930-1935	45.8	20.9	24.9
1935-1939	45.2	20.5	24.7
1940-1943	42.1	18.7	23.4
Developmental Period			
1950-1954	45.9	10.1	35.8
1955-1959	42.6	7.9	34.7
1960-1964	36.5	6.3	30.2
1965-1969	29.6	5.3	24.3
1970	27.2	4.9	22.3

SOURCES: Data for traditional period from Statistical Summary of Taiwan for the Past 51 Years. Data for developmental period from Taiwan Provincial Department of Civil Affairs, Taiwan Demographic Fact Book, Taichung, 1971.

exerted a greater offsetting effect which resulted in a net gain of six years of working life for males at age fifteen during the period from 1915 to 1940 (see Table 3.10). The female participation rate was especially sensitive to changes in the economic environment. Female participation increased at first in response to the need for agricultural laborers, but decreased in subsequent periods as the burden of childcare became greater. Participation rose again when the war broke out in 1940. This pattern reflects the observation that in traditional rural society women join in direct agricultural production if their responsibility for raising children does not fully occupy their time. Both activities were viewed as productive by the Japanese. The shift from direct production to childcare at that time was economically desirable. It was a policy that proved to be more efficient than otherwise would have been the case.

The diffused effects of the reduction in mortality can easily be detected by examining the components of the increase in economically active males. Table 3.11 shows that the rising rate of variation resulted largely from an increase in the rate of entry of young people into the labor force and a decrease in the rate of withdrawals due to deaths; the effect of the increase in the retirement rate was negligible. The increase in the rate of entry also benefited from the reduction in the death rate of young mothers. An obvious example is that when uncontrolled influenza invaded the island during the period from 1915 to 1920, the rate of entry, withdrawals due to deaths, and thus the rate of variation were all affected.

The components of variation in the participation rate for the agricultural labor force provide further information on the effects

TABLE 3.10 COMPARISON OF TOTAL POPULATION AND ECONOMICALLY ACTIVE POPULATION

	1905	1915	1920	1930	1940	1950	1960	1970
		Male						
Total population	1,611	1,814	1,894	2,535	2,971	4,380	5,991	7,643
Population aged 12 and over	1,160	1,264	1,328	1,553	1,850	3,056	3,803	5,242
Economically active population	1,090	1,165	1,181	1,372	1,608	2,654	3,003	3,798
Economically active pop. as % of:								
Total population	67.4	64.2	62.4	58.3	54.1	60.6	50.1	49.7
Population aged 12 and over	94.0	92.2	88.9	88.3	86.9	86.8	79.0	72.4
Net years of working life								
at birth	-	19.7	20.6	25.8	27.0			
at 15 years of age	-	29.5	30.9	35.2	36.3			
		Female						
Total population	1,429	1,667	1,762	2,239	2,901	3.666	5,181	6,862
Population aged 12 and over	1,028	1,149	1,225	1,466	1,830	2,403	3,106	4,598
Economically active population	314	478	456	418	635	764	721	1,244
Economically active pop. as % of:								
Total population	22.0	28.7	25.9	18.7	21.9	20.8	13.9	18.1
Population aged 12 and over	30.5	41.6	37.2	78.5	34.7	31.8	23.2	27.0

SOURCES: The same as for Table 3.8.

of aggregate demand on the economic characteristics of the population (see Table 3.11). Except during the influenza epidemic, which caused all components to work in opposite directions, nearly all the new entrants were directed to an occupation in which they were needed by the colonial government, i.e., to agriculture during the period from 1905 to 1930 and to industries during the period from 1930 to 1940.

TABLE 3.11 COMPONENTS OF THE AVERAGE ANNUAL CHANGE PER 1,000 OF TAIWAN'S ECONOMICALLY ACTIVE MALE POPULATION

Period	Entry	Deaths	Retirement	Variation
		Economically Active Population		
1905–1915	33.5	24.5	2.1	6.9
1915–1920	31.2	26.2	2.6	2.4
1920–1930	38.0	19.0	3.5	15.5
1930–1940	39.2	18.0	3.3	17.9
		Agricultural Labor Force		
1905–1915	31.5	23.7	2.1	5.7
1915–1920	26.9	25.5	5.6	4.1
1920–1930	35.3	18.1	2.2	15.0
1930–1940	31.0	18.2	8.0	4.8

SOURCES: Based on data from the Population Census Reports and Vital Statistical Books for the respective years.

With respect to the measures for improving the efficiency of the labor force, the intention of the colonial government to develop the economy of Taiwan as complementary to Japan's economy was notoriously clear.[3] It is well known that the greatest handicap to agricultural

development in a traditional society is the conservative attitude of farmers. If the spread of modern education is the only way to change people's attitudes, better education will also inspire enthusiasm for better living and even more, for political rights. The education policies under Japanese rule were designed to provide only for the improvement of agricultural productivity. These policies are evidenced by the fact that the enrollment rate in primary school increased steadily from 21 percent for boys and 4 percent for girls in 1917 to 81 percent and 61 percent in 1943 respectively. Few Taiwanese were admitted to higher levels of education. Opportunities for education at the university level were virtually denied the indigenous population. The highest number of students entering the university never exceeded ninetypersons per year and all were enrolled in fields other than the social and political sciences. Government spending on education per person was about NT$ .60 to 1.00 per year for the whole period under the Japanese occupation (at 1952 to 1956 prices, equivalent to US$ .026 to .043). Returns on this spending, however, were extraordinarily high. It is estimated that a new Taiwan dollar spent on rural education led to a discounted long-run social return of 14 dollars to farm output during the period from 1920 to 1940.[4]

It has been observed that an increasing supply of labor had been efficiently and economically obtained by means of minimizing the costs of rearing and training population on the one hand and by reducing waste of human resources due to poor health and deaths on the other. The increased labor force was largely used to develop agriculture during the period from 1905 to 1930. Thereafter the industrial sector began to absorb the labor force at a rapidly growing rate. The shift

in direction of labor flow was a response to the call of the Japanese empire to support the Pacific war. It had, however, at the same time eased the population pressures on resources resulting from the actions to increase the labor force. This may be seen from the fact that in spite of a drastic drop in the net entry into the agricultural force from 15 per 1000 active males in the period from 1920 to 1930 to 5 per 1000 in the 1930s (see Table 3.11), the cultivated land area per farm increased only from 2.0 to 2.2 hectares, while the irrigated land area remained almost constant during the same period. These facts indicate that if the demand had not changed from agricultural products to industrial goods in the period from 1930 to 1945 most of the new workers would have had to stay on farms and hence each farmer would have worked on a smaller plot of land. Unless there were significant improvement in technology or innovation in production organization, the returns on marginal labor would have decreased.

Although the shift of demand from agricultural to industrial products eased the population pressures on the limited land and water resources, it created new needs for capital, technology, and entrepreneurship. These needs in general were met by limiting current consumption and launching mass education and research programs. In Taiwan, as noted before, the consumption of the indigenous population had already been driven to the subsistence level while better education was discouraged by the Japanese regime. Therefore most investment was financed by the annual agricultural surplus through the Japanese authorities. Openings for skilled workers, technicians, and managers were nearly all filled by Japanese nationals. The Taiwanese population supplied mainly manual or semiskilled workers. These

workers were generally kept away from modern contacts. Their incomes were not substantially different from those of farm workers. Even then, for Taiwanese workers who acquired new technical training, their remuneration was only about half to two-thirds that of their Japanese counterparts. As a result, industrialization brought neither improvement in standard and style of living nor modern attitudes to the population at large. Moreover, the influence of industrialization on population growth was retarded by these colonial policies. The familiar industrial fertility differentials and the negative relationship between industrialization and fertility were never observed in the period from 1930 to 1945, although this might have been largely due to the short time period.

The immediate impact of World War II on the economy of Taiwan was severe. Economic and human resources were mobilized to support the Japanese war endeavor. Industrial plants, power stations, transportation facilities, and irrigation networks were badly destroyed by Allied bombing attacks. At the end of the war Japanese skilled workers, technicians, and managers were expatriated. Adding to these problems were the typhoons and floods which devastated the war-torn economy. Consequently, both industrial and agricultural production declined sharply. Industrial output in 1945 was about one-third, and agricultural output about one-half of the peak rates of 1939. In spite of war casualties, the death rate decreased gradually to 19 deaths per 1000 population, the lowest rate recorded to that time. Because of war separations, the birth rate declined to 42 per 1000 population for the same period.

2. The Developmental Period: 1945-1970

a. General Background

In 1945 Taiwan was restored to China and became a province of the Republic of China. Immediately following the restoration several important events occurred in the economy. The first was a recognition of consumers' sovereignty. As noted in the previous section, the colonial government had been the only influential decision-maker in the sphere of the general population's economic life. Denying the rights of decision-making to individuals paralyzed the normal functioning of the price system. As a result, part of the expected relationship between economic growth and population change was inoperable. After Taiwan's return to China, the basic impairment of the normal workings of the economic and demographic relationship was remedied by giving back these individual rights.

The second important event was the massive inflow of mainland Chinese. The population register shows that a total of approximately 500,000 civilians migrated to Taiwan in a brief period around the late 1940s. At the same time, it was estimated that about 600,000 military men were stationed on the island. A sudden huge increase in population was indeed a burden to a relatively small economy. But, the contributions of these migrants to economic development depended greatly on the condition that physical resources could be adequately mobilized. About two-thirds of the civilian migrants were young males with special technical, professional, or administrative training. A few even brought with them sizeable amounts of capital. They filled not only the technical gap owing to the repatriation of the Japanese but also the positions needed for the development of new import substitute

industries. The military forces added little to direct economic production but their contribution to the maintenance of peace was invaluable.

The third event was the implementation during 1949 to 1953 of a series of land reforms. First, rentals on farm land were ordered reduced from the prevailing rate of 50 percent or more to 37.5 percent of the main crop produced on the land. Second, some 72,000 hectares of publicly owned land were sold to the tillers. And 144,000 hectares of land owned by landlords whose holdings were over 3 hectares were compulsorily purchased by the government and resold to the tenants. The price of land, for both the seller and the buyer, was 2.5 times the annual value of the main crop produced thereon. It was paid in terms of 20 semiannual installments. The tenants paid the government in kind -- rice or sweet potatoes; the landlords received from the government 70 percent in produce and 30 percent in government-owned industries. On the whole, 344,000 tenants benefited: they were able to purchase 320,000 hectares of farm land from the landlords or the government.

These three events occurred immediately after the restoration changed the basic economic setting of Taiwan. The recognition of consumers' sovereignty and the huge inflow of human resources had long-lasting favorable effects on the growth of the free enterprise economy. The implementation of land reforms through the enforcement of restrictions on land holding and rents was beneficial to incipient development but these arrangements seem also to have been an obstacle to the mechanization and modernization of farms. As industrial expansion proceeds, the need for farm mechanization is increasingly

urgent. Under the principle of preserving the spirit of land reforms, the government has experimented with various ways to consolidate small farming units into large farm units to facilitate the use of farm machinery. A socially acceptable and practical program has not yet been satisfactorily worked out. Thus, the agrarian arrangements throughout the period from 1951 to 1970 remained unchanged. These arrangements, however, are expected to be the subject of reform in the very near future.

With these changes in the economic system in mind we may examine the chain relation between aggregate demand and the growth and distribution of population in this period in contrast to those of the colonial period.

b. Aggregate Demand

Since Taiwan's economy recovered from war destruction the level and pattern of aggregate demand havebeen determined primarily by the decisions of household and business firms. The government was only empowered to assist in carrying out the individuals' decisions. Therefore its direct influence on demand was insignificant as compared to that of the Japanese rulers. However, the indirect influence of the government was far-reaching.

As individuals became responsible for their own economic welfare and their income and consumption were primarily determined by market forces, decisions concerning the pattern of demand were more responsive to the effects of population, relative prices, national income, and international market conditions. In the early 1950s the rate of population growth reached its highest peak of 36 per 1000 population (see Table 3.9). This unprecedentedly high increase plus the

brief but huge inflow of mainland Chinese caused a great immediate need for consumer goods, especially for necessities. The net saving rate, as a result, diminished to less than 5 percent at that time. The low rate of saving limited the ability to export and to further develop the economy. Fortunately, the timely inflow of U. S. aid assisted a monetary reform in forestalling demand pull price inflation on the one hand, and helped in the implementation of various development programs on the other. With this external assistance Taiwan's economy was able to escape from the Malthusian trap. Thereafter population growth was no longer an appalling factor, although its pressure on resources was felt in one form or another throughout the entire period under review.

The effects of population on aggregate demand are interacting and cumulative. A general equilibrium economic-demographic model developed in the former chapter gives a detailed treatment of this problem. For present purposes the population effect may be simply separated out by examining the per capita values of the components of aggregate demand.

Although the hyper-inflation which might have been ignited by the sudden increase in demand due to rapid population growth had been prevented, the amplitude of changes in price levels was not brought down to a normal range until the late 1960s (see Table 3.12). Furthermore, the changes were not uniformly distributed (see Table 3.12, right panel). The index of government consumption registered the highest rate of increase throughout the period from 1951 to 1970. This was mainly due to the continuous upward adjustment of the pay scale of government employees and military personnel who (especially

TABLE 3.12 ANNUAL RATE OF PRICE CHANGE AND RELATIVE PRICE CHANGE

	1951-55 ∫ 1956-60	1956-60 ∫ 1961-65	1961-65 ∫ 1966-70	1951-55 ∫ 1956-60	1956-60 ∫ 1961-65	1961-65 ∫ 1966-70
	Annual Rate of Price Change			Relative Change in Price		
Private Consumption	10.1	5.6	3.0	0.86	0.93	0.94
Food	10.9	6.9	3.3	0.92	1.15	1.03
Clothing	6.2	2.5	0.6	0.52	0.42	0.19
Shelter	11.2	3.7	3.4	0.95	0.62	1.06
Services	5.1	4.0	1.1	0.43	0.66	0.34
Health	10.0	4.0	2.0	0.85	0.67	0.62
Education	6.0	2.2	1.8	0.51	0.37	0.56
Government Consumption	13.4	9.4	8.4	1.14	1.57	2.62
Administration	13.4	9.4	8.4	1.14	1.57	2.62
Health	13.4	9.4	8.4	1.14	1.57	2.62
Education	13.4	9.4	8.4	1.14	1.57	2.62
Gross Fixed Capital Formation	16.4	4.8	1.6	1.39	0.80	0.50
Exports	17.5	7.1	1.3	1.48	1.20	0.41
Total Aggregate Demand	11.8	6.0	3.2	1.00	1.00	1.00

SOURCE: Based on data from Directorate-General of Budgets, Accounts and Statistics, Executive Yuan, National Income of the Republic of China, Taipei, 1971.

the latter) had been underpaid in comparison with other trades. The next highest persistent relative increase was in the price of food. This was a reflection of the rise in real costs induced by population pressures on land. The land constraint on agricultural expansion, however, had forced Taiwan to diversify its production activities, both for export expansion and import substitution. The sharp declines in the relative prices of exports, fixed capital formation, and clothing were an indication of success in product diversification. The relative prices of shelter and services would also have declined if the items in these categories had been more homogeneous. In fact, various modern consumer durables were introduced in the 1960s. Prices were generally high at first and then gradually declined as production expanded.

On the whole, the changes in relative prices had a significant effect on the pattern of aggregate demand. The comparison of the composition of demand measured at current prices with that at 1966 prices presented in Table 3.13 shows that the relative importance of the components differs from one time period to another.

Accordingly, the per capita values at constant prices provide a more exact measure of the real changes in aggregate demand. It is seen from Table 3.14 that the real per capita value of aggregate demand more than doubled during the twenty-year period. The fastest growing component was exports; the growth of capital demand ranked next; private consumption expanded a little more slowly than the average; and government expenditures grew most slowly. Thus, exports and capital formation played an increasingly important role in the growth of aggregate demand.

Demand elasticity (which is defined as the ratio of the percentage increase in per capita demand in each category to the percentage

TABLE 3.13 THE COMPOSITION OF TAIWAN'S AGGREGATE DEMAND

	1951 ∫ 1955	1956 ∫ 1960	1961 ∫ 1965	1966 ∫ 1970	1951 ∫ 1955	1956 ∫ 1960	1961 ∫ 1965	1966 ∫ 1970
	Percentage							
	At Current Prices				At Constant 1966 Prices			
Private Consumption	66.3	60.3	56.8	47.3	60.7	58.3	55.9	47.0
Food	40.2	35.8	32.0	24.4	40.3	37.0	32.1	24.3
Clothing	4.0	3.4	3.0	2.6	2.7	2.8	2.9	2.8
Shelter	11.1	10.7	10.3	9.4	9.7	.96	10.1	9.1
Services	4.9	4.4	4.5	5.0	3.4	3.9	4.3	4.8
Health	4.1	2.6	3.7	2.8	2.4	2.3	3.5	2.8
Education	3.3	3.2	3.2	3.2	2.1	2.5	3.0	3.2
Government Consumption	15.8	17.2	15.3	14.4	21.3	22.0	17.4	13.4
Administration	14.5	14.6	13.0	11.5	19.4	18.7	14.8	10.7
Health	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.3
Education	1.1	2.2	2.0	2.6	1.5	2.9	2.2	2.5
Gross Fixed Capital Formation	10.6	13.1	13.6	17.5	9.7	10.5	13.2	18.4
Exports	7.3	9.4	14.4	20.7	8.4	9.2	13.5	21.2
Total Aggregate Demand in million NT$	23,998	54,196	103,693	209,521	52,825	74,953	110,071	191,467

SOURCE: The same as for Table 3.12.

TABLE 3.14 THE AGGREGATE DEMAND PER PERSON AND DEMAND ELASTICITIES

	1951 ∫ 1955	1956 ∫ 1960	1961 ∫ 1965	1966 ∫ 1970	1951-55 ∫ 1956-60	1956-60 ∫ 1961-65	1961-65 ∫ 1966-70	1951-55 ∫ 1966-70
	Demand per Person in 1966 NT$				Demand Elasticity with Respect to			
Private Consumption	3,615	4,178	5,049	6,485	0.77	0.80	0.54	0.60
Food	2,402	2,659	2,895	3,356	0.44	0.34	0.30	0.30
Clothing	163	203	263	381	1.45	1.14	0.85	1.02
Shelter	587	686	911	1,257	0.92	1.27	0.72	0.89
Services	203	281	389	663	1.89	1.48	1.33	1.72
Health	142	168	319	391	0.90	3.47	0.43	1.33
Education	127	181	271	437	2.09	1.92	1.16	1.86
Government Consumption	1,267	1,574	1,568	1,846	1.19	0.01	0.34	0.34
Administration	1,158	1,339	1,335	1,470	0.77	0.01	0.19	0.20
Health	19	30	32	36	2.85	0.25	0.24	0.68
Education	90	203	201	340	6.18	0.04	1.31	2.11
Gross Fixed Capital Formation	576	754	1,191	2,531	1.52	2.24	2.13	2.58
Exports	499	662	1,216	2,926	1.61	3.23	2.66	3.70
Total Aggregate Demand	5,958	7,168	9,024	13,788	1.00	1.00	1.00	1.00

SOURCE: The same as for Table 3.12.

increase in total demand per capita) is a rough but convenient measure. Demand elasticities are presented in Table 3.14. As might be expected, expenditures on food were inelastic with respect to the changes in total demand, and those on clothing, shelter, services, health, and education, in general, were elastic. The high response of shelter and services expenditures to total demand was mainly due to the widespread availability of modern consumer durables such as radios, motorcycles, television sets, and so forth. Outlays on health and education were also highly elastic.

The effect of the change in direction of consumption expenditures was favorable to economic development. First, it relieved to some extent population pressures on land by diverting economic activities from agriculture to industries. Second, it changed the attitudes and prospects of the general population. Education has long proven to be an effective factor in modernizing ideas. Two recent economic-demographic surveys, however, show that families who own more modern consumer goods tend to be more modern in their economic and fertility behavior.[5]

The relation between total demand per capita and per capita government consumption was not as stable as private consumption for the period under review. This might be largely due to the fact that most government expenditures, such as those for military expenditures, outlays for extension of compulsory education from six to nine years in the late 1960s, and for the salaries paid to government employees were made with little consideration of income levels. In general, it appears that expenditures for government consumption tended to grow more slowly than income.

An increasingly large proportion of gross fixed capital formation

was a reflection of private and government consumption. The remainder was attributable to external assistance. The income effect on capital formation, as seen by its elasticity, was accelerating. This obviously resulted from the multiplier effect of investment on income.

Most of the developing countries rely heavily on exports as one of their main sources of income. These exports are constituted in large, however, by primary products which are characterized by fluctuating prices. As a consequence, the production of these exportables and thus income suffers from a high degree of instability. Taiwan developed into a supplier of agricultural products under the Japanese occupation. The influence of their colonial policies on export composition did not fade immediately, but the market for exports changed from one of a Japanese monopoly to one of an international competitive market. With concentration of exports in a few primary products, the economy was ready for this drastic change. To cope with the new situation, efforts in export diversification were especially emphasized by the government. As a result, the share of agricultural products in exports dropped from a high of 93 percent in the period from 1955 to 1954 to 22 percent in 1970 (see Table 3.1). Income growth consequently was outstripped by the expansion of exports with an increasingly large margin over the period from 1951 to 1970 (see Table 3.14).

In brief, aggregate demand in Taiwan's economy changed from one predominantly agriculturally oriented to one of industry orientation after the return of Taiwan to China. The agriculture-oriented demand was imposed by the colonial rulers while the industry-oriented demand was largely governed by the forces of the free market. Contrary to the workings of the colonial economy, population, relative prices, and

income functioned much more fully in determining the level and pattern of aggregate demand under the system of market economy.

c. Economic Structure and Population Dynamics

With changing aggregate demand the resources of the economy were reallocated to meet new needs, partly by the working of the price mechanism and partly by the influences of government policies. One of the distinguished features of the government policies was the encouragement of balanced growth of agriculture and industries. This policy has proven to be beneficial both to economic growth and modernization of the population. As noted, the completion of agrarian reform in the early 1950s boosted agricultural production in an already overcrowded rural economy. However the reforms also alleviated the unemployment problem and stimulated incentives to regulate family size. With respect to the unemployment problem, the land reforms stimulated the farmers to use land more intensively than before. Therefore a large number of young job seekers who were born in the colonial period were retained in agriculture. With regard to motives for fertility control, the custom of the inheritance of equal shares of land or tenantship among sons (although daughters might have small shares for their dowries) made farmers more conscious of the economic consequences of having large families, for before the implementation of land reform the new entrants into agriculture could compete with their fellow tenants to obtain the right to make a living on the land. The consequences of rapid population growth therefore were shared among all the tenants. Individuals suffered only the loss of marginal productivity of the economy as a whole. After the agrarian reform, the possiblity of obtaining a piece of land, either by purchasing or by renting, was very

rare. For in general the titles of land and tenantships were passed over generation to generation with equal shares among the descendants. The average area of cultivated land per farm in 1950 had already been reduced to 1.4 hectares. For efficient use it was technically and economically impossible to divide the land into smaller plots. With this imminent threat, strong motives for regulating family size arose among farmers. For those who had large families, pressure for land enhanced their motives for preparing some of the family members to take up jobs outside the farm. These aims, however, would not have been materialized if the farmers had had to engage in endless repetition and to be isolated as they had been before. In the developmental period the chances of being exposed to modern contacts did increase greatly. Opportunities for higher education opened to the general population with virtually no cost. Mass media and communications expanded: the circulation of daily newspapers increased more than three times in the period from 1951 to 1970. The average number of radios per 1000 families rose from 33 in 1951 to 551 in 1970. Television was introduced in 1965 and by 1970 every 1000 families had 195 sets. The number of telephone receivers per 1000 families increased from 39 in 1951 to 95 in 1970. Public health services, including a family planning program started in 1963, had extended to remote areas. But the fundamental determinants of the modernization were the changes in economic activities among and between the agricultural and nonagricultural population.

Table 3.4 shows that total agricultural output reattained its highest previous peak, attained in 1935, by 1950, but output per farm caught up with its 1935 level about fifteen years later -- in 1965. The sluggish growth of farm productivity was largely attributable to a

rapid increase in the number of household farms while accompanying factors were not able to expand simultaneously (see Tables 3.3 and 3.4). As indicated by the declining trend of cultivated land and irrigated land area per farm the limitation of land and water resources appeared to be irresistible. Since the techniques of rice and sugar cane cultivation were already highly developed, further increases in the production of these crops became increasingly difficult. To break through the bottleneck, efforts were directed to developing marketable crops which were landsaving (by using either little or inferior land) and labor-intensive. These endeavors were rewarding. From 1952 to 1970 output of rice rose only by 57 percent, and of sugar cane by 25 percent. On the contrary, bananas, pineapples, and citrus fruits, which had a prosperous export market, expanded by 332 percent, 439 percent, and 653 percent respectively.[6] Output of soybeans, an import substitute, increased by 346 percent. Harvest of fish and production of pork, more for domestic consumption than for export, rose by 405 percent and 240 percent respectively. Mushrooms and asparagus were newly introduced and also constituted a substantial share of exports. It is seen that the sharp increase in total and per-farm output was made possible by diversification rather than repetition of agricultural activities. Furthermore, these outputs were all produced for the market. As a result, profit and loss had gradually replaced social values as the determinants of economic activities in the rural community. In addition, rationalization of economic behavior consequently led the farmers to modern attitudes toward family size.[7]

As a whole, agricultural production was able to maintain an average annual growth rate of 5 percent during the period from 1951 to 1970.

This remarkable achievement not only met the food requirements of the increasing population but also produced a surplus to support industrial development in the double sense of financing demographic and material investment and of providing an extended market for industries.

It is seen from Table 3.15 that the farm income (from labor and property) in the agricultural sector grew from 3.8 percent in the 1950s to 4.7 percent in the 1960s. The per capita farm income, however, rose rapidly from 1.1 percent to 3.1 percent in the same period. This high rate of increase obviously resulted from a sharp decline in the growth rate of agricultural population in the late 1960s. Two factors governed the tendency of decline in the rural population: (1) an increase in the rate of net out-migration from the agricultural to the nonagricultural sector, and (2) a decrease in the rate of natural increase owing to the drop in the birth rate in excess of the drop in the death rate (see Table 3.16).

The success of the land reforms of 1940 to 1953 absorbed into agriculture a large inflow of young workers who were a result of the high rate of natural growth, the balance of constant high birth rate and low death rate, in the 1930s. Since then the agricultural sector has become saturated with abundant labor. It was estimated that during the period from 1951 to 1955 only 64 percent of the farm workers were fully employed. Irrespective of the increase in production and out-migration in later years, the situation of underemployment was not much improved. The bulk of the underemployed were unpaid family workers, most of whom were young workers or women helpers (see Tables 3.15 and 3.17). This fact added to the effects of inheritance customs engendered a strong push force on rural-industrial mobility.

TABLE 3.15 POPULATION, LABOR FORCE, AND INCOME IN THE AGRICULTURAL AND NONAGRICULTURAL SECTORS

	1951 ∫ 1955	1956 ∫ 1960	1961 ∫ 1965	1966 ∫ 1970	1951-55 ∫ 1956-60	1956-60 ∫ 1961-65	1961-65 ∫ 1966-70
Population (000)	8,754	10,316	12,031	13,697	3.6	3.3	2.8
Agricultural pop.	4,378	4,934	5,599	5,981	2.5	2.7	1.4
Nonagr. pop.	4,376	5,382	6,432	7,716	4.7	3.9	4.0
Labor Force (000)	2,959	3,184	3,603	4,304	1.5	2.6	3.9
Agriculture	1,802	1,832	1,969	2,141	0.3	1.5	1.7
Full-time equivalent employed	1,160	1,284	1,358	1,676	2.1	1.2	4.7
Full-time equivalent employed* as % of agri. workers	64.4	70.1	69.0	78.3			
Nonagriculture	1,157	1,352	1,634	2,163	3.4	4.2	6.5
Income (Property and Labor, Million 1966 NT$)	38,108	50,220	72,286	112,102	6.4	8.8	11.0
Agriculture	11,930	14,217	17,093	21,122	3.8	4.0	4.7
Nonagriculture	26,178	36,003	55,193	90,980	7.5	10.7	13.0
Per Capita Income (1966 NT$)	8,707	9,571	11,634	15,322	2.0	4.3	6.3
Agriculture	2,725	2,881	3,053	3,531	1.1	1.2	3.1
Nonagriculture	5,982	6,690	8,581	11,791	2.7	5.7	7.5
Ratio of Per Capita Income in Agr. to Nonagr.	0.46	0.43	0.36	0.30			
Ratio of Labor Income to Property Income in Nonagr.	1.88	2.11	2.08	2.22			

SOURCES: Income data from the same source as for Table 3.12. Agricultural population from Agricultural Year Book. Labor force data from the Registration Reports.

*Full-time equivalent employed was computed by dividing the total number of days worked on farm in a year into 200 days. The total number of days worked on farms in a year was estimated by the Joint Commission on Rural Reconstruction.

TABLE 3.16 VITAL RATES FOR AGRICULTURAL AND NONAGRICULTURAL POPULATIONS

	1956 ∫ 1969	1961 ∫ 1965	1966 ∫ 1970
	Agricultural Population		
Birth Rate	42.1	37.5	35.5
Death Rate	8.4	6.7	5.9
Rate of Natural Increase	33.7	30.8	29.6
Net Migration Rate	8.3	3.8	16.0
Rate of Increase	25.4	27.0	13.6
	Nonagricultural Population		
Birth Rate	39.5	33.5	27.1
Death Rate	5.9	5.0	4.6
Rate of Natural Increase	33.6	28.5	22.5
Net Migration Rate	13.4	10.5	17.4
Rate of Increase	47.0	39.0	39.9

SOURCES: Based on Registration Reports for the respective periods.

TABLE 3.17 COMPOSITION OF EMPLOYED PERSONS BY STATUS

	Total	Employers	Self-employed Workers	Unpaid Family Workers	Paid Employees
			Male		
Agriculture					
1956	100.0	1.8	56.6	30.7	10.9
1966	100.0	1.3	57.7	31.9	9.1
1971	100.0	1.1	56.8	24.2	20.9
Nonagriculture					
1956	100.0	5.6	20.3	4.1	70.0
1966	100.0	3.8	12.4	2.7	80.1
1971	100.0	4.6	19.2	3.1	73.1
			Female		
Agriculture					
1956	100.0	0.6	17.2	74.8	7.0
1966	100.0	0.5	23.2	70.5	5.5
1971	100.0	0.2	11.8	76.4	11.6
Nonagriculture					
1956	100.0	2.8	14.7	10.2	71.0
1966	100.0	3.1	11.6	8.3	77.0
1971	100.0	1.8	12.4	16.0	69.8

SOURCES: Data for 1956 and 1966 taken from the Population Census Reports for the respective years. Data for 1971 taken from Taiwan Provincial Social Affairs Department, Labor Force Survey, 1971.

In addition, the rapid expansion of the nonagricultural sector (the gross domestic product grew 12 percent per year in the period from 1951 to 1970) raised the per capita income of nonfarmers about 6 percent per year on the average. Consequently, the difference in earnings between the two sectors increasingly widened (see Table 3.15). This constituted a force pulling rural workers from their usual economic activities. Both the push and pull forces acted to accelerate rural-industrial mobility. The problem of urban unemployment recently prevailing in most of the developing countries, especially those in South America and Africa, did not seriously strike Taiwan. The basic reasons why Taiwan was able to evade this plague may be explored from the agricultural and nonagricultural sides.

In the 1950s Taiwan was confronted with unemployment problems of the same nature as those faced now by most of the developing countries, because the initial phase of "demographic revolution," i.e., constant high fertility matched with declining mortality, had taken place in Taiwan about twenty years earlier. The fact that this did not turn out to be a disaster was largely due to the implementation of land reform, serving as a buffer in the course of readjusting the economy. Thereafter, the rural sector benefited so that it was able to provide the redundant labor force with adequate education or training while withholding workers until nonagricultural employment was available. In this, economic calculation was not totally absent. There was a tendency to coin a norm with regard to the newly emerged problem. In general the eldest son on the household farm took up the family business with full-time participation and supported younger brothers who continued their formal education or training beyond the compulsory requirements as far as their abilities

permitted. The younger brothers helped with farm chores in the busy seasons, and usually reported as farmers if they were not enrolled in a formal school. After they had been employed or had established themselves off the farm their income and prestige were higher than those of siblings remaining on farms. Economic compensation to the latter was made more or less according to their losses, although usually not explicitly in the form of cash payments. The common practice was that those who worked on the farm had the privilege of acquiring the absentee brothers' shares of land with little or no payment in return. Those who left the farm also took a large share in supporting their parents. These informal arrangements helped to solve the problems of fragmentation and the uneconomical size of land holdings on the one hand and facilitated a less painful approach to the underemployment problem on the other.

Taiwan was the most densely populated country in the world, 408 persons per square kilometer in 1970, and its cities were crowded. The expansion of industries in or around urban centers therefore was prohibited by an exceedingly high land price. On the contrary, there were some advantages to locating industries in the countryside. First, land prices were relatively lower. Next, transportation on the island was convenient and inexpensive. Third, location in rural areas gave accessibility to a labor force. Last, a government policy of preparing industrial sites and infrastructures throughout the island to aid local development provided facilities which would usually be found only in urban areas. As a result, most of the new manufacturing plants were constructed in the countryside, hence opportunities for nonagricultural employment in rural areas increased with the progress of industrialization.

The primary effect of the widely dispersed industrialization

was that the change from traditional to modern economic activities was necessarily associated neither with change in residence from rural to urban, nor with the need to break cultural and social contacts in the rural community. According to two consecutive surveys on rural labor mobility, among those who had nonfarm jobs, the commuters, i.e., those who worked in the nonagricultural sector but stayed with their parents or brothers on a farm, increased from 20 percent in 1963 to 48 percent in 1968.[8] This form of transformation, in contrast to rural-urban migration, greatly alleviated the urgent pressure on resources for housing and public services in the cities. Instead, a gradual improvement in living conditions was carried out in accordance with the individuals' and communities' abilities enhanced by an increase in productivity. More importantly, the commuters brought new ideas and values from their places of work to rural society, causing a gradual adjustment with little conflict between the modern and traditional personalities.

We have noted that under the present social and economic arrangements, economic considerations have been gaining importance in the determination of the size of the family. It is postulated that in the earlier period of demographic transition the change in attitudes and hence behavior did not involve a confrontation with the traditional familial values, i.e., having three or four children with at least one or two sons. As mortality had declined steadily for some time, the persistently high fertility produced more surviving children than were needed for the ideal family size supported by social values. The economically justified small families could therefore be achieved by the control of excess births. As economic development proceeded economic aspiration intensified as a growing population (resulting from

traditional values) still constituted a threat to economic welfare, so that a change in attitudes toward ideal family size occurred in due time. Statistical evidence, contained in Tables 3.18 to 3.23, appears to support this argument. First, there was a continuous marked decline in mortality rates, especially for the younger age groups, during the period from 1950 to 1970. Then, after a short time-lag, a fertility decline occurred among women of almost all ages. The rate of decline was increasingly high for women over thirty years of age. This decline, as shown by Table 3.20, is partly attributable to the decline in the proportion married in younger age groups, but mainly attributable to the sharp decline in the rate of births to married women over thirty. The decrease in the number of wives who wanted no more children while using no contraception was obviously related to the decline in the marital fertility rate. The sluggishness in the decrease in the number of children desired by wives after a substantial fall in fertility seemed to imply that economic pressures had not yet gained their full momentum. However, the educational and rural-urban differentials in ideal family size in 1970 are a signal that traditional values are giving way to rationalized calculations.

3. Summary

The preceeding sections demonstrate that the level and pattern of aggregate demand dominated the relationships between demographic trends and socioeconomic development of Taiwan for the past seventy years. There were two distinct types of aggregate demand: the traditional occurred during the period of the Japanese occupation from 1895 to 1945; and the developmental type, continuing at present, developed at

TABLE 3.18 AGE-SPECIFIC DEATH RATE FOR EACH SEX AND PERCENT CHANGE FOR TAIWAN, 1950-1970

Age	Age-Specific Death Rate			Percent Change		
	1950	1960	1970	1950-60	1960-70	1950-70
			Male			
0	41.56	34.11	10.49	-17.95	-69.25	-74.76
1-4	24.28	7.55	2.28	-68.90	-69.80	-90.61
5-9	3.24	1.23	0.71	-62.04	-42.28	-78.74
10-14	2.34	0.92	0.62	-60.68	-32.61	-73.50
15-19	2.21	1.36	1.26	-38.46	- 7.35	-42.99
20-24	3.47	2.18	1.82	-37.16	-16.51	-47.55
25-29	4.26	2.42	2.02	-43.19	-16.53	-52.58
30-34	5.44	3.03	2.54	-44.49	-15.89	-53.31
35-39	6.31	4.06	3.20	-35.66	-21.18	-49.29
40-44	10.44	5.82	4.13	-44.25	-29.04	-60.44
45-49	14.01	7.74	6.52	-44.75	-15.76	-53.46
50-54	20.44	13.23	10.36	-35.27	-21.69	-49.32
55-59	30.82	21.30	15.02	-30.89	-29.48	-51.27
60-64	43.62	31.57	28.12	-27.62	-10.93	-35.53
65-69	58.04	51.33	44.12	-11.56	-14.05	-23.89
70+	127.75	112.76	96.59	-11.73	-14.34	-24.39
			Female			
0	38.03	30.66	9.73	-19.38	-68.26	-74.41
1-4	26.35	8.24	2.05	-68.73	-75.12	-92.22
5-9	3.53	1.02	0.53	-71.10	-48.04	-84.99
10-14	2.04	0.66	0.46	-67.65	-30.30	-77.45
15-19	2.24	1.26	0.73	-43.75	-42.06	-67.41
20-24	3.49	1.79	0.94	-48.71	-47.49	-73.07
25-29	4.23	1.95	1.15	-53.90	-41.03	-72.81
30-34	5.16	2.44	1.61	-52.71	-34.02	-68.80
35-39	6.26	3.06	2.00	-51.12	-34.64	-68.05
40-44	8.85	4.02	2.75	-54.58	-31.59	-68.93
45-49	10.95	5.05	4.14	-53.88	-18.02	-62.19
50-54	15.84	7.99	6.60	-49.56	-17.40	-58.33
55-59	21.32	12.38	9.22	-41.93	-25.53	-56.75
60-64	30.18	19.59	17.20	-35.09	-12.20	-43.01
65-69	41.46	32.30	27.98	-22.09	-13.37	-32.51
70+	96.78	88.00	79.28	- 9.07	- 9.91	-18.08

SOURCES: Based on data from Demographic Fact Book 1970 and Taiwan Demography, Vol. 5, No. 7, July 1970.

TABLE 3.19 AGE-SPECIFIC BIRTH RATES AND OTHER FERTILITY RATES FOR ALL WOMEN AND PERCENT CHANGE FOR TAIWAN, 1950-1970

Age	Rate Per 1,000 Women					Percentage Change in Rates				
	1950	1955	1960	1965	1970	1950-55	1955-60	1960-65	1965-70	1950-70
15-19	61	50	48	36	40	-18.0	- 4.0	-25.0	-11.1	-34.4
20-24	246	273	253	261	238	11.0	- 7.3	3.2	- 8.8	- 3.3
25-29	297	341	333	326	293	14.8	- 2.3	- 2.1	-10.1	- 1.3
30-34	269	295	255	195	147	9.7	-13.6	-23.5	-24.6	-45.4
35-39	191	219	169	100	59	14.7	-22.8	-40.8	-41.0	-69.1
40-44	112	103	79	41	20	- 8.0	-23.3	-48.1	-51.2	-82.1
45-49	30	25	13	6	3	-16.7	-48.0	-53.8	-50.0	-90.0
General Fertility Rate	181	197	180	152	120	8.8	- 8.6	-15.6	-21.1	-33.7
Total Fertility Rate	6,030	6,530	5,750	4,825	4,000	8.3	-11.9	-16.1	-17.1	-33.7

SOURCES: Based on data from Demographic Fact Books, 1961 to 1970.

TABLE 3.20 PROPORTION OF WOMEN CURRENTLY MARRIED, MARITAL FERTILITY RATE, AND PERCENT CHANGE FOR TAIWAN, 1960-1970

Age of Women	Proportion or Rate			Percent Change		
	1960	1965	1970	1960-65	1965-70	1958-70
	Proportion Currently Married					
15-19	12.4	9.2	8.0	-25.8	-17.0	-35.5
20-24	62.3	58.3	50.3	- 6.4	-13.7	-19.3
25-29	89.3	88.8	88.1	- 0.6	- 0.8	- 1.4
30-34	91.3	92.8	93.0	1.6	0.2	1.9
35-39	89.6	91.5	93.2	2.1	1.8	4.0
40-44	85.7	88.0	90.6	2.7	3.0	5.7
45-49	79.0	83.3	85.7	5.4	2.9	8.5
	Marital Fertility Rate					
15-19	300	390	502	± 0	28.7	28.7
20-24	407	447	473	9.8	5.8	16.2
25-29	373	368	332	- 1.4	- 9.8	-11.0
30-34	279	210	158	-24.7	-24.8	-43.4
35-39	189	109	64	-42.3	-41.3	-66.1
40-44	92	47	22	-48.9	-53.2	-76.1
45-49	16	8	4	-50.0	-50.0	-75.0
General Fertility Rate	264	225	192	-11.4	-14.7	-27.3
Total Fertility Rate	8,730	7,895	7,775	- 9.6	- 1.5	-10.9

SOURCE: Based on data from Demographic Fact Book, 1970.

TABLE 3.21 PROPORTION OF WIVES WANTING NO MORE CHILDREN AND USING NO CONTRACEPTION IN TAIWAN, 1965-1970

Age	1965	1967	1970	Percent difference 1965-1970
22-24	8.4	8.0	6.1	-27
25-29	24.2	18.6	17.2	-29
30-34	42.0	32.8	25.8	-38
35-39	53.7	37.3	30.1	-44

SOURCE: R. Freedman, A. Hermalin, and T. H. Sun, "Fertility Trends in Taiwan: 1961-1970," Population Index, Vol. 38, No. 2, April-June 1972.

TABLE 3.22 WIFE'S DESIRED NUMBER OF CHILDREN BY WIFE'S AGE FOR TAIWAN, 1965, 1967, 1970

Age	1965	1967	1970	Percent Change 1965-1970
22-24	3.73	3.56	3.56	-4.6
25-29	3.76	3.59	3.56	-5.3
30-34	4.05	3.92	3.80	-6.2
35-39	4.29	4.10	4.06	-5.4
40-44	4.38	4.30	4.23	-3.4
Total	4.02	3.91	3.80	-5.5

SOURCE: The same as for Table 3.21.

TABLE 3.23 WIFE'S DESIRED NUMBER OF CHILDREN, BY WIFE'S AGE AND EDUCATION AND BY TYPE OF PLACE OF RESIDENCE, 1970

Wife's Education	Wife's Age 22-29	Wife's Age 30-39	Type of Place of Residence	Wife's Age 22-29	Wife's Age 30-39
Senior high school	2.8	3.3	Large city	3.3	3.7
Junior high school	3.4	4.0	Small city	3.3	3.8
Primary school	3.7	4.6	Urban township	3.6	3.9
None	4.0	4.9	Rural township	3.8	4.1
Total	3.6	3.9	Total	3.6	3.9

SOURCE: The same as for Table 3.21.

the time of the restoration of Taiwan to the Republic of China in 1945.

The traditional type was agriculturally oriented demand with an aim of maximizing the agricultural surplus exported to a foreign economy. In order to maintain peace and order, the traditional agrarian values and the small-scale family farming system were preserved. The maximization of surplus was achieved by duplicating farm units and raising productivity through the use of better seeds, fertilizers, and irrigation while depressing the living standard of the general population to the lowest possible level. The traditional society thus engaged in years of repetitious work and ways of consumption. Engel's law (the basic drive for change in a domestic demand pattern) was prevented from functioning by the fixity of disposable income. The external demand pattern was directly controlled by the colonial rulers. Therefore, the normal interrelationships between population growth and economic development were inoperable, even though industrialization spread in the late 1930s.

In the developmental period, the structure of Taiwan's economy and the trends of its population appear to have been mainly determined by an industrially oriented demand. The resumption of the working of the price system, a large but brief influx of mainland Chinese, and the implementation of land reform during the early 1950s formed a basic setting for the last twenty years of economic and demographic development. External demand was freed from Japanese domination and opened to the competitive world market. Domestic demand was subject to the influence of the variables of population, relative prices, and national income. The changing demand led to a change in the economic activities of the work force. Agricultural production became more and more labor intensive and market oriented. Industrial development penetrated the

countryside. The problem of labor absorption was gradually dissolved through the mutual support of agriculture and nonagriculture. Traditional attitudes and behavior toward family size were increasingly rationalized on the basis of economic calculations.

Footnotes

[1]Yhi-Min Ho, Agricultural Development of Taiwan 1903-1960 (Kingsport, Tennessee: Vanderbilt Press, 1966); and S. C. Hsieh and T. H. Lee, An Analytical Review of Agricultural Development in Taiwan--An Input-output and Productivity Approach, (Taipei, Taiwan: Joint Commission on Rural Reconstruction, 1958).

[2]Han-Yu Chang and R. H. Myers, "Japanese Colonial Development Policy in Taiwan, 1895-1906: A Case Study of Bureaucratic Entrepreneurship," Journal of Asian Studies, Vol. XVII (August 1963).

[3]S. P. S. Ho, "The Development Policy of the Japanese Colonial Government in Taiwan, 1895-1945," in G. Ranis, ed., Government and Economic Development (New Haven, Connecticut: Yale University Press, 1971), pp. 287-331.

[4]Chang and Myers, "Japanese Colonial Development," p. 7.

[5]Yhi-Min Ho, Agricultural Development, p. 121.

[6]D. Freedman, "The Role of the Consumption of Modern Durables in Economic Development," Economic Development and Cultural Change, Vol. 19, No. 1 (October 1970), pp. 25-48; "The Consumption of Modern Goods and Services and Their Relation to Fertility in Taiwan," mimeographed (Ann Arbor, Michigan: The University of Michigan, 1971); and "The Relationship of Family Planning to Savings and Consumption in Taiwan," Demography, Vol. 9, No. 3 (August 1972), pp. 499-506.

[7]Commission on International Economic Cooperation and Development, Taiwan Statistical Data Book (Taipei, Taiwan: CIECD, 1971).

[8]E. Mueller, "Economic Motives for Family Limitation," mimeographed (Ann Arbor, Michigan: The University of Michigan, 1971); and "Agricultural Change and Fertility Change: The Case of Taiwan," mimeographed (Ann Arbor, Michigan: The University of Michigan, 1972).

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CHAPTER IV. THE ECONOMIC-DEMOGRAPHIC MODEL APPLIED TO TAIWAN

1. Introduction

From the preceding chapter on the history of Taiwan's economy and population it is seen that the development of Taiwan may be divided into two periods; (1) the colonial, 1895 to 1945, and (2) the developmental, 1945 to 1970. The colonial period was a time of extensive agricultural development although in the last decade of it some industrial factories were set up. Partly due to the shortness of time elapsed but mainly due to the colonial policies, the impact of industrialization had not permeated through the economy as had been experienced in the advanced countries. The developmental period, however, was characterized by the development of labor-intensive industries. The relationships between population change and economic development functioned as in the advanced economies.

In our theoretical model, the colonial period of Taiwan is analogous to the growth phase of the agricultural development stage, and the developmental period is analogous to the industrial stage. There is, however, a fundamental difference between the model and the empirical case of Taiwan. In the model we have assumed that the complex of political and social factors has continuously and gradually evolved hand in hand with economic development. Actually, Taiwan had experienced radical changes in its political and social environment during

World War II. Unless all these shifts can be properly incorporated in each of the behavior equations in the model, any attempt to treat the colonial and developmental periods simultaneously in a single model would be practically impossible. Moreover, this attempt would also be prevented by the fact that statistical information for the colonial period is not as detailed as that for the developmental period. Confronted with these practical difficulties we have decided to choose the developmental period for the statistical test of the interactions between population growth and economic development because: (1) what happened in this period is much more interesting and relevant to contemporary public concern, and (2) the available statistical information permits us to explore the interactions in greater detail and depth.

In the discussion of the theoretical framework we have attempted to show the main features and the workings of the whole system; some detailed parts of the model and links between various variables are purposely omitted to avoid tediousness. In estimating the equations, however, we have to include these details in order to close the system. They are the behavioral equations for consumption, foreign market, and wage-price determination; and the identities.

2. Numerical Estimates of the Model

The system of equations has been estimated from sample data from twenty annual observations, from 1951 to 1970. The system consists of 107 stochastic equations and 33 identities. All equations were estimated by the method of two-stage-least-squares. In the first stage the 24 exogenous variables were combined into 5 principal components which explained 98 percent of the total variation.[1] These five principal

components were used as instrumental variables to get the regressors of the endogenous variables in the second stage. The estimated equations are presented as follows. The $\underline{t}$ statistics of the parameter estimates are reported in the parentheses below the coefficients. Values of these statistics in excess of 2.54 suggest the parameter is different from zero at the 1 percent level, using the one-tailed test. R^2 is the coefficient of determination (not adjusted for the degree of freedom). D is the Durbin-Watson statistic and S is the standard error of the regression. Following the equations is a list of all variables in alphabetical order, with their definitions and with exogenous variables noted by an asterisk.

The system is linear in the unknown parameters but it is nonlinear in the variables. The estimated parameters from the sample data may be explained in terms of the standard linear model.

Production function

$$\underset{(0.078)}{\text{GDPA} = 1.4585e^{\underset{(3.308)}{0.0241t}}\ \underset{(1.441)}{KA^{0.5604}}\ \underset{(1.441)}{LA^{0.4396}}} \quad (1)$$

$$R^2 = 0.780 \quad D = 1.595 \quad S = 0.0445$$

$$\underset{(0.798)}{\text{GDPN} = 34.0017e^{\underset{(16.587)}{0.0603t}}\ \underset{(0.777)}{KN^{\underset{(0.5)}{0.2882}}}\ \underset{(0.777)}{LN^{0.7118}}} \quad (2)$$

$$R^2 = 0.987 \quad D = 0.902 \quad S = 0.0395$$

$$\underset{(0.350)}{\text{GDPN} = 6.1080e^{\underset{(12.728)}{0.0624t}}\ \underset{(0.994)}{KN^{\underset{(0.0)}{0.4315}}}\ \underset{(0.994)}{LN^{0.5685}}} \quad (2a)$$

$$R^2 = 0.989 \quad D = 0.844 \quad S = 0.0368$$

$$\underset{(0.937)}{\text{GDPN} = 53.3581e^{\underset{(19.125)}{0.0596t}}\ \underset{(0.702)}{KN^{\underset{(0.75)}{0.2507}}}\ \underset{(0.702)}{LN^{0.7493}}} \quad (2b)$$

$$R^2 = 0.986 \quad D = 0.914 \quad S = 0.0404$$

(2c) $GDPN = 85.7038e^{0.0590t}\ KN^{0.2111}_{(1.00)}\ LN^{0.7889}$

(1.130) (22.228) (0.636) (0.636)

$R^2 = 0.986$ D = 0.931 S = 0.0412

(2d) $GDPN = 120.9488e^{0.0586t}\ KN^{0.1823}_{(1.25)}\ LN^{0.8177}$

(1.301) (25.091) (0.586) (0.586)

$R^2 = 0.986$ D = 0.943 S = 0.0418

(2e) $GDPN = 120.5582e^{0.0586t}\ KN^{0.1801}_{(1.50)}\ LN^{0.8199}$

(1.115) (24.903) (0.503) (0.503)

$R^2 = 0.986$ D = 0.950 S = 0.0406

(2f) $GDPN = 252.8132e^{0.0579t}\ KN^{0.1206}_{(2.00)}\ LN^{0.8794}$

(1.835) (31.553) (0.476) (0.476)

$R^2 = 0.985$ D = 0.969 S = 0.0430

Proportion of labor force engaged in the nonagricultural sector

(3) $LNM_{15} = -2.0677 + 3.9338\ DTDN - 0.0049\ DWN$

(4.924) (3.752) (0.017)

$R^2 = 0.713$ D = 0.958 S = 0.173

(4) $LNM_{20} = -2.1220 + 3.9836\ DTDN + 0.0161\ DWN$

(4.396) (3.306) (0.049)

$R^2 = 0.669$ D = 1.073 S = 0.199

(5) $LNM_{25} = -1.9867 + 4.0950\ DTDN - 0.0670\ DWN$

(3.815) (3.150) (0.189)

$R^2 = 0.616$ D = 1.225 S = 0.2151

(6) $LNM_{35} = -1.8391 + 4.0633\ DTDN - 0.1209\ DWN$

(3.316) (2.934) (0.320)

$R^2 = 0.557$ D = 1.247 S = 0.840

(7) $LNM_{45} = -1.7557 + 4.2322\ DTDN - 0.2050\ DWN$
(3.314) (3.200) (0.568)

$R^2 = 0.560 \quad D = 1.122 \quad S = 0.766$

(8) $LNM_{55} = -1.6475 + 3.8466\ DTDN - 0.1753\ DWN$
(4.117) (3.850) (0.643)

$R^2 = 0.654 \quad D = 0.879 \quad S = 0.165$

(9) $LNM_{65} = -1.9944 + 4.1811\ DTDN - 0.1150\ DWN$
(5.813) (4.882) (0.492)

$R^2 = 0.779 \quad D = 0.883 \quad S = 0.142$

(10) $LNF_{15} = -2.2259 + 4.5340\ DTDN - 0.0888\ DWN$
(5.552) (4.530) (0.325)

$R^2 = 0.761 \quad D = 0.854 \quad S = 0.166$

(11) $LNF_{20} = -2.3178 + 4.8832\ DTDN - 0.1337\ DWN$
(5.331) (4.500) (0.451)

$R^2 = 0.748 \quad D = 0.764 \quad S = 0.179$

(12) $LNF_{25} = -1.8788 + 4.0386\ DTDN - 0.1305\ DWN$
(5.392) (4.643) (0.550)

$R^2 = 0.752 \quad D = 0.711 \quad S = 0.144$

(13) $LNF_{35} = -1.5286 + 3.5172\ DTDN - 0.1593\ DWN$
(4.556) (4.199) (0.697)

$R^2 = 0.691 \quad D = 0.630 \quad D = 0.138$

(14) $LNF_{45} = -1.4421 + 3.2779\ DTDN - 0.1415\ DWN$
(4.617) (4.204) (0.665)

$R^2 = 0.696 \quad D = 0.690 \quad S = 0.129$

(15) $LNF_{55} = -1.7034 + 3.9445\ DTDN - 0.1894\ DWN$
(4.860) (4.508) (0.793)

$R^2 = 0.717 \quad D = 0.588 \quad S = 0.145$

(16) LNF_{65} = -2.1104 + 4.8369 DTDN -0.2184 DWN
(4.645) (4.265) (0.705)

R^2 = 0.705 D = 1.085 S = 0.188

Age specific birth rate

(17) $ASBR_{15}$=0.1623 -0.0275 VPLN -14.887 $VPK_{(0.5)}$ + .0348 DWA
(1.579) (0.018) (1.563) (0.772)

R^2 = 0.666 D = 1.601 S = 0.00308

(17a) $ASBR_{15}$ = 0.1027 + 0.9945 VPLN -9.1425 $VPK_{(0.5)}$ + 0.000049 VDE
(1.575) (0.833) (1.431) (0.0204)

R^2 = 0.700 D = 1.123 S = 0.00292

(17b) $ASBR_{15}$ = -0.1827 + 4.4947 VPLN + 13.3407 $VPK_{(0.5)}$ + 0.0049 IUD_{15}
(0.826) (1.681) (0.759) (1.329)

R^2 = 0.801 D = 1.437 S = 0.00237

(18) $ASBR_{20}$ = -0.0399 + 5.1252 VPLN + 21.3959 $VPK_{(0.5)}$ -0.0224 DWA
(0.143) (1.234) (0.825) (0.183)

R^2 = 0.404 D = 1.406 S = 0.00839

(18a) $ASBR_{20}$ = -0.0498 -0.8031 VPLN + 32.8384 $VPK_{(0.5)}$ + 0.0128 VDE
(0.224) (0.198) (1.509) (1.563)

R^2 = 0.164 D = 1.520 S = 0.00994

(18b) $ASBR_{20}$ = -0.8691 + 17.0280 VPLN + 81.9124 $VPK_{(0.5)}$ + 0.0032 IUD_{20}
(1.906) (2.715) (2.326) (2.134)

R^2 = 0.262 D = 1.673 S = 0.00934

(19) $ASBR_{25}$ = 0.4508 -1.3524 VPLN -9.5128 $VPK_{(0.5)}$ + 0.0073 DWA
(1.402) (0.2791) (0.359) (0.076)
-0.0015 IUD_{25}
(3.424)

R^2 = 0.870 D = 2.581 S = 0.00664

(20) $ASBR_{30} = \underset{(1.413)}{0.6939} + \underset{(0.840)}{6.2307}\ VPLN - \underset{(1.670)}{67.7318}\ VPK_{(0.5)} + \underset{(0.360)}{0.0544}\ DWA - \underset{(4.033)}{0.0018}\ IUD_{30}$

$R^2 = 0.972 \quad D = 1.156 \quad S = 0.01033$

(21) $ASBR_{35} = \underset{(1.269)}{0.8810} + \underset{(0.629)}{6.4816}\ VPLN - \underset{(1.751)}{99.2074}\ VPK_{(0.5)} + \underset{(0.298)}{0.0585}\ DWA - \underset{(2.778)}{0.0019}\ IUD_{35}$

$R^2 = 0.962 \quad D = 1.164 \quad S = 0.01344$

(22) $ASBR_{40} = \underset{(0.997)}{0.4645} + \underset{(0.616)}{4.1162}\ VPLN - \underset{(1.538)}{57.7513}\ VPK_{(0.5)} + \underset{(0.711)}{0.0764}\ DWA - \underset{(1.689)}{0.0011}\ IUD_{40}$

$R^2 = 0.960 \quad D = 1.420 \quad S = 0.00734$

(23) $ASBR_{45} = \underset{(1.399)}{-0.6110} + \underset{(2.006)}{11.4277}\ VPLN + \underset{(1.166)}{40.8567}\ VPK_{(0.5)} - \underset{(0.206)}{0.0097}\ DWA + \underset{(1.578)}{0.0024}\ IUD_{45}$

$R^2 = 0.898 \quad D = 1.069 \quad S = 0.00316$

Survival Ratio

(24) $SURM_b = \underset{(138.935)}{0.9824} - \underset{(0.6821)}{0.0671}\ VPDI - \underset{(1.917)}{0.0061}\ VDH$

$R^2 = 0.918 \quad D = 0.836 \quad S = 0.0041$

(25) $SURM_5 = \underset{(420.245)}{0.9967} + \underset{(1.412)}{0.0466}\ VPDI - \underset{(2.697)}{0.0029}\ VDH$

$R^2 = 0.783 \quad D = 0.636 \quad S = 0.0014$

(26) $SURM_{10} = 0.9971 - 0.0209\ VPDI + 0.0004\ VDH$
(417.781)(0.629) (0.348)

$R^2 = 0.911$ D = 2.664 S = 0.0014

(27) $SURM_{15} = 0.9938 - 0.0021\ VPDI - 0.0005\ VDH$
(990.310)(0.154) (1.224)

$R^2 = 0.950$ D = 1.629 S = 0.000005

(28) $SURM_{20} = 0.9951 + 0.0033\ VPDI - 0.0017\ VDH$
(534.862)(0.129) (2.007)

$R^2 = 0.880$ D = 0.688 S = 0.000018

(29) $SURM_{25} = 0.9889 + 0.0450\ VPDI - 0.0028\ VDH$
(379.465)(1.241) (2.374)

$R^2 = 0.705$ D = 0.869 S = 0.00150

(30) $SURM_{30} = 0.9875 + 0.0331\ VPDI - 0.0028\ VDH$
(415.457)(1.002) (2.651)

$R^2 = 0.822$ D = 1.043 S = 0.000030

(31) $SURM_{35} = 0.9340 + 0.0315\ VPDI - 0.0035\ VDH$
(342.774)(0.789) (2.708)

$R^2 = 0.864$ D = 0.730 S = 0.00165

(32) $SURM_{40} = 0.9747 + 0.0727\ VPDI - 0.0058\ VDH$
(197.332)(1.057) (2.590)

$R^2 = 0.788$ D = 0.604 S = 0.0028

(33) $SURM_{45} = 0.9532 + 0.1002\ VPDI - 0.0070\ VDH$
(192.492)(1.453) (3.117)

$R^2 = 0.819$ D = 0.826 S = 0.0028

(34) $SURM_{50} = 0.9545 - 0.0935\ VPDI - 0.0035\ VDH$
(91.981) (0.647) (0.737)

$R^2 = 0.754$ D = 1.961 S = 0.00597

(35) $SURM_{55} = 0.9266 - 0.2324\ VPDI - 0.0007\ VDH$
(158.140) (2.849) (0.264)

$R^2 = 0.942 \quad D = 2.183 \quad S = 0.00337$

(36) $SURM_{60} = 0.8675 - 0.2246\ VPDI - 0.0015\ VDH$
(94.815) (1.764) (0.362)

$R^2 = 0.885 \quad D = 1.999 \quad S = 0.00526$

(37) $SURM_{65} = 0.7988 - 0.2104\ VPDI - 0.0072\ VDH$
(54.234) (1.026) (1.085)

$R^2 = 0.884 \quad D = 1.723 \quad S = 0.00848$

(38) $SURM_{70} = 0.6930 - 0.3171\ VPDI - 0.0018\ VDH$
(40.226) (1.322) (0.235)

$R^2 = 0.807 \quad D = 1.938 \quad S = 0.00157$

(39) $SURM_{75} = 0.4810 - 1.8054\ VPDI - 0.0785\ VDH$
(7.588) (2.046) (2.739)

$R^2 = 0.481 \quad D = 1.165 \quad S = 0.03647$

(40) $SURF_b = 0.9931 - 0.0948\ VPDI - 0.0074\ VDH$
(165.002) (1.132) (2.724)

$R^2 = 0.961 \quad D = 0.809 \quad S = 0.00346$

(41) $SURF_5 = 0.9968 + 0.0665\ VPDI - 0.0037\ VDH$
(325.811) (1.561) (2.646)

$R^2 = 0.729 \quad D = 0.543 \quad S = 0.00176$

(42) $SURF_{10} = 0.9980 + 0.1233\ VPDI - 0.0012\ VDH$
(826.492) (0.734) (2.2721)

$R^2 = 0.899 \quad D = 0.441 \quad S = 0.000695$

(43) $SURF_{15} = 0.9982 - 0.0093\ VPDI - 0.0008\ VDH$
(779.470) (0.521) (1.440)

$R^2 = 0.919 \quad D = 0.644 \quad S = 0.000737$

(44) $SURF_{20} = 0.9973 + 0.0032\ VPDI - 0.0017\ VDH$
$(535.820)(0.124) \quad (2.013)$

$R^2 = 0.880 \quad D = 0.690 \quad S = 0.00107$

(45) $SURF_{25} = 0.9957 + 0.0203\ VPDI - 0.0026\ VDH$
$(437.925)(0.641) \quad (2.541)$

$R^2 = 0.880 \quad D = 0.724 \quad S = 0.00131$

(46) $SURF_{30} = 0.9938 + 0.03926\ VPDI - 0.0038\ VDH$
$(339.940)(0.964) \quad (2.917)$

$R^2 = 0.865 \quad D = 0.649 \quad S = 0.00168$

(47) $SURF_{35} = 0.9909 + 0.05176\ VPDI - 0.0048\ VDH$
$(259.959)(0.975) \quad (2.758)$

$R^2 = 0.842 \quad D = 0.716 \quad S = 0.00219$

(48) $SURF_{40} = 0.9836 + 0.0938\ VPDI - 0.0064\ VDH$
$(182.412)(1.250) \quad (2.642)$

$R^2 = 0.748 \quad D = 0.599 \quad S = 0.00310$

(49) $SURF_{45} = 0.9750 + 0.1023\ VPDI - 0.0071\ VDH$
$(192.472)(1.450) \quad (3.119)$

$R^2 = 0.825 \quad D = 0.826 \quad S = 0.00291$

(50) $SURF_{50} = 0.9720 - 0.0269\ VPDI - 0.0040\ VDH$
$(309.302)(0.616) \quad (2.810)$

$R^2 = 0.952 \quad D = 1.528 \quad S = 0.00181$

(51) $SURF_{55} = 0.9476 - 0.0017\ VPDI - 0.0059\ VDH$
$(185.777)(0.023) \quad (2.557)$

$R^2 = 0.916 \quad D = 1.380 \quad S = 0.00293$

(52) $SURF_{60} = 0.9044 + 0.0353\ VPDI - 0.0077\ VDH$
$(133.585)(0.375) \quad (2.513)$

$R^2 = 0.887 \quad D = 2.244 \quad S = 0.00024$

(53) $SURF_{65} = \underset{(53.551)}{0.8490} \underset{(0.576)}{-0.1270}\ VPDI \underset{(1.293)}{-0.0093}\ VDH$

$R^2 = 0.856 \quad D = 1.690 \quad S = 0.00912$

(54) $SURF_{70} = \underset{(40.207)}{0.7507} \underset{(1.316)}{-0.3420}\ VPDI \underset{(0.239)}{-0.0020}\ VDH$

$R^2 = 0.807 \quad D = 1.938 \quad S = 0.0107$

(55) $SURF_{75} = \underset{(12.040)}{0.5378} \underset{(2.264)}{-1.4075}\ VPDI + \underset{(2.947)}{0.0595}\ VDH$

$R^2 = 0.492 \quad D = 1.437 \quad S = 0.02570$

Labor force participation rate

(56) $LPM_{15} = \underset{(1.181)}{3.7882} + \underset{(0.472)}{0.0107}\ PK_{(0.5)} + \underset{(3.687)}{0.0625}\ PLN$

$R^2 = 0.685 \quad D = 0.988 \quad S = 0.1640$

(57) $LPM_{20} = \underset{(0.692)}{-3.3979} + \underset{(0.028)}{0.00097}\ PK_{(0.5)} + \underset{(3.100)}{0.0803}\ PLN$

$R^2 = 0.649 \quad D = 0.804 \quad S = 0.2508$

(58) $LPM_{25} = \underset{(0.922)}{-5.2250} + \underset{(0.220)}{0.0088}\ PK_{(0.5)} + \underset{(3.440)}{0.1030}\ PLN$

$R^2 = 0.677 \quad D = 0.801 \quad S = 0.2896$

(59) $LPM_{30} = \underset{(0.945)}{-5.4046} + \underset{(0.240)}{0.0097}\ PK_{(0.5)} + \underset{(3.468)}{0.1048}\ PLN$

$R^2 = 0.678 \quad D = 0.801 \quad S = 0.2923$

(60) $LPM_{35} = \underset{(0.967)}{-5.5317} + \underset{(0.261)}{0.0105}\ PK_{(0.5)} + \underset{(3.493)}{0.1056}\ PLN$

$R^2 = 0.679 \quad D = 0.800 \quad S = 0.2923$

(61) $LPM_{40} = \underset{(0.964)}{-5.4547} + \underset{(0.257)}{0.01026}\ PK_{(0.5)} + \underset{(3.493)}{0.1045}\ PLN$

$R^2 = 0.680 \quad D = 0.804 \quad S = 0.2892$

(62) $LPM_{45} = \underset{(0.947)}{-5.2340} + \underset{(0.241)}{0.0094}\ PK_{(0.5)} + \underset{(3.476)}{0.1015}\ PLN$

$R^2 = 0.679 \quad D = 0.790 \quad S = 0.2824$

(63) $LPM_{50} = \underset{(1.038)}{-5.3626} + \underset{(0.333)}{0.0121}\ PK_{(0.5)} + \underset{(3.550)}{0.0969}\ PLN$

$R^2 = 0.678 \quad D = 0.816 \quad S = 0.2639$

(64) $LPM_{55} = \underset{(1.144)}{-4.8179} + \underset{(0.402)}{0.0120}\ PK_{(0.5)} + \underset{(3.775)}{0.0840}\ PLN$

$R^2 = 0.702 \quad D = 0.808 \quad S = 0.2153$

(65) $LPM_{60} = \underset{(0.446)}{-1.2905} \underset{(0.212)}{-0.0043}\ PK_{(0.5)} + \underset{(2.861)}{0.0437}\ PLN$

$R^2 = 0.644 \quad D = 0.807 \quad S = 0.1480$

(66) $LPM_{65} = \underset{(.439)}{0.5333} \underset{(0.975)}{-0.0083}\ PK_{(0.5)} + \underset{(1.644)}{0.0106}\ PLN$

$R^2 = 0.550 \quad D = 0.976 \quad S = 0.0621$

(67) $LPF_{15} = \underset{(0.617)}{-2.2480} + \underset{(1.261)}{0.0545}\ PK_{(0.5)} \underset{(2.742)}{-84.1123}\ ASBR_{15}$

$R^2 = 0.385 \quad D = 1.371 \quad S = 0.2093$

(68) $LPF_{20} = \underset{(3.077)}{5.5555} \underset{(2.962)}{-0.0491}\ PK_{(0.5)} + \underset{(0.077)}{0.5119}\ ASBR_{20}$

$R^2 = 0.354 \quad D = 0.510 \quad S = 0.1900$

(69) $LPF_{25} = \underset{(5.471)}{4.1337} \underset{(1.818)}{-0.0143}\ PK_{(0.5)} \underset{(4.484)}{-7.3495}\ ASBR_{25}$

$R^2 = 0.702 \quad D = 1.739 \quad S = 0.0880$

(70) $LPF_{30} = \underset{(0.011)}{0.0086} + \underset{(0.926)}{0.0073}\ PK_{(0.5)} \underset{(6.687)}{-3.0649}\ ASBR_{30}$

$R^2 = 0.860 \quad D = 1.199 \quad S = 0.06312$

(71) $LPF_{35} = \underset{(1.259)}{-1.2291} + \underset{(1.803)}{0.0166}\ PK_{(0.5)} \underset{(7.120)}{-3.3676}\ ASBR_{35}$

$R^2 = 0.870 \quad D = 1.191 \quad S = 0.0668$

(72) $LPF_{40} = \underset{(1.474)}{-1.6753} + \underset{(1.874)}{0.01992}\ PK_{(0.5)} \underset{(6.238)}{- 6.4176}\ ASBR_{40}$

$R^2 = 0.836 \quad D = 1.318 \quad S = 0.0732$

(73) $LPF_{45} = \underset{(1.544)}{-2.4728} + \underset{(0.783)}{0.0088}\ PK_{(0.5)} \underset{(4.195)}{+ 0.0355}\ PLN$

$R^2 = 0.715 \quad D = 0.982 \quad S = 0.0818$

(74) $LPF_{50} = \underset{(1.251)}{-1.5507} + \underset{(0.486)}{0.0042}\ PK_{(0.5)} \underset{(3.952)}{+ 0.0259}\ PLN$

$R^2 = 0.716 \quad D = 0.954 \quad S = 0.634$

(75) $LPF_{55} = \underset{(1.166)}{-0.9026} + \underset{(0.414)}{0.0023}\ PK_{(0.5)} \underset{(3.833)}{+ 0.0157}\ PLN$

$R^2 = 0.710 \quad D = 1.022 \quad S = 0.0395$

(76) $LPF_{60} = \underset{(0.034)}{0.0115} \underset{(0.693)}{-0.0017}\ PK_{(0.5)} \underset{(2.810)}{+ 0.0046}\ PLN$

$R^2 = 0.594 \quad D = 1.013 \quad S = 0.0197$

(77) $LPF_{65} = \underset{(0.742)}{0.0948} \underset{(1.239)}{-0.0011}\ PK_{(0.5)} \underset{(1.229)}{+ 0.00083}\ PLN$

$R^2 = 0.513 \quad D = 1.276 \quad S = 0.00068$

Saving and capital formation

(78) $DF = \underset{(1.108)}{29499.5976} + \underset{(5.358)}{0.1872}\ PDI + \underset{(2.605)}{3.4283}\ NPC \underset{(1.150)}{-44760.0000}\ DPF$

$R^2 = 0.995 \quad D = 2.310 \quad S = 721.219$

(79) DC = 3820.6540 + 0.0622 PDI -0.2758 NP -1495.6357 DPC
(0.885) (9.070) (1.270) (0.758)

R^2 = 0.988 D = 1.070 S = 189.492

(80) DSH = -1479.7204 + 0.1578 PDI + 0.7588 NH
(0.625) (7.172) (0.403)

R^2 = 0.988 D = 1.795 S = 571.165

(81) DSV = 24321.6625 + 0.2046 PDI -2.0461 NP -8647.7383 DPSV
(0.376) (0.942) (0.451) (0.355)

R^2 = 0.969 D = 1.948 S = 583.201

(82) DH = 8736.5039 + 0.0192 PDI + 0.3467 NP -10311.6875 DPH
(0.949) (1.053) (1.665) (1.324)

R^2 = 0.958 D = 1.199 S = 390.273

(83) DE = -623.8013 + 0.0144 PDI + 0.1589 NPS + 0.7752 DE_{t-1}
(1.460) (1.050) (0.701) (5.054)

R^2 = 0.995 D = 1.818 S = 154.014

(84) TXB = 146.9888 + 0.0399 PR -383.4619 DM
(2.483) (7.510) (2.1242)

R^2 = 0.920 D = 0.948 S = 147.329

(85) TXD = 296.5710 -0.0783 WBA + 0.0578 WBN
(2.813) (4.620) (11.174)

R^2 = 0.974 D = 2.491 S = 146.513

(86) TXI = -6035.6094 + 0.1799 TD -261.2478t
(10.739) (13.221) (1.841)

R^2 = 0.988 D = 0.889 S = 1082.42

(87) GH = -305.4609 + 0.0073 GR + 0.0435 NP
(3.244) (1.848) (2.855)

R^2 = 0.922 D = 1.797 S = 41.405

(88) $I = -20.9918 - 2.1516\ Q + 0.2845\ PK_{(0.5)}$
(0.493) (1.918) (0.696)

$R^2 = 0.290$ D = 1.209 S = 1.7258

(89) $GIP = -4927.8711 + 0.1060\ GDP$
(11.307) (24.683)

$R^2 = 0.973$ D = 1.116 S = 784.139

Imports and exports

(90) $MK = -171.0859 + 0.6049\ I$
(0.692) (34.844)

$R^2 = 0.986$ D = 2.164 S = 701.029

(91) $MR = 4309.2071 + 0.0514\ GDPN + 0.5735\ XN$
(5.069) (2.749) (10.708)

$R^2 = 0.992$ D = 2.016 S = 888.932

(92) $XA = 344.5781 + 1.0194\ XA_{t-1}$
(0.623) (14.862)

$R^2 = 0.927$ D = 1.858 S = 989.331

(93) $XN = -32.0195 + 1.3487\ XN_{t-1}$
(0.174) (86.720)

$R^2 = 0.998$ D = 2.466 S = 641.232

Liquidity preference

(94) $MD = -8396.5000 - 8324.8633\ Q + 1093.8850\ PK_{(0.5)}$
(0.492) (1.851) (0.667)

$R^2 = 0.289$ D = 1.0962 S = 7166.39

Wages and prices

(95) $WA = -5.5489 + 6.2486\ PGC + 0.5082\ DGDPA - 0.0124\ U$
(0.721) (2.554) (2.270) (1.814)

$R^2 = 0.937$ D = 0.643 S = 0.882

(96) WN = -12.0068 + 2.2550 PGC + 0.7199 DGDPN -0.0022 U
(1.941) (0.756) (9.089) (0.262)

R^2 = 0.995 D = 1.105 S = 0.731

(97) PA = 0.1412 + 0.0671 WA + 0.3432 PI =0.00006 GDPA
(.740) (2.290) (2.183) (0.467)

R^2 = 0.973 D = 0.775 S = 0.0455

(98) PN = 0.1823 + 0.0172 WN + 0.4467 PI -0.0000004 GDPN
(3.138) (1.434) (3.766) (0.172)

R^2 = 0.986 D = 1.794 S = 0.0290

(99) PF = -0.0270 + 0.5542 PA + 0.4760 PN
(1.300) (5.348) (4.194)

R^2 = 0.996 D = 1.363 S = 0.01738

(100) PC = 0.3870 + 0.4611 PI + 0.1461 PM
(4.808) (1.589) (0.624)

R^2 = 0.900 D = 1.312 S = 0.0452

(101) PSH = 0.2548 -0.1489 PI + 0.9560 PM
(2.374) (0.385) (3.064)

R^2 = 0.932 D = 0.863 S = 0.0603

(102) PSV = 0.3397 + 0.5242 PN + 0.0067 WN
(5.178) (3.498) (1.811)

R^2 = 0.969 D = 1.379 S = 0.0337

(103) PH = 0.1191 + 0.3386 PN + 0.5632 PH_{t-1}
(3.772) (2.491) (4.033)

R^2 = 0.974 D = 1.829 S = 0.0339

(104) PE = 0.2652 + 0.0054 WN + 0.6430 PE_{t-1}
(2.777) (2.193) (4.462)

R^2 = 0.918 D = 2.072 S = 0.0464

(105) PG = -0.4083 + 1.3683 PGC
(5.755) (16.793)

R^2 = 0.943 D = 0.417 S = 0.0776

(106) PI = 0.2598 -0.0495 PN + 0.8352 PM
(4.241) (0.222) (4.237)

R^2 = 0.928 D = 0.950 S = 0.0592

(197) PCS = 0.2090 + 0.3206 PN + 0.4566 PM
(4.635) (1.960) (3.147)

R^2 = 0.953 D = 1.250 S = 0.0436

Identities

1. DF + DC + DSH + DSV + DH + DE + INA + INN + DA + DN + CS + GA + GE + GH + EXPA + EXPN - MK - MR - MC = GDPA + GDPN = GDP
2. PF*DF + PC*DC + PSH*DSH + PSV*DSV + PH*DH + PE*DE + PI*(INA + INN + DA + DN) + PCS*CS - PM*(MK + MR + MC) + PG*(GA + GH + GE) + PX*(EXPA + EXPN) = PA*GDPA + PN*GDPN = P*GDP
3. TDA = DF + EXPA
4. TDN = DF + DC + DSH + DSV + DH + DE + INA + INN + DA + DN + CS + GA + GE + GH + EXPN
5. TD = TDA + TDN
6. D = PI*(DA + DN)
7. NI = P*GDP - NFI - TXI - D
8. PY = NI - (TXB + GIP - IPB) + TFH - THG - TXD
9. PR = NI - WBA - WBN
10. WA = WBA / LA
11. WN = WBN / LN
12. PDI = PY / PGC

13. $PGC = (PF*DF + PC*DC + PSH*DSH + PSV*DSV + PH*DH + PE*DE) / (DF + DC + DSH + DSV + DH + DE)$

14. $GR = (TXB + TXD + TXI + GIP + THG + TFG - IPB) / PG$

15. $SP = PDI - (DF + DC + DSH + DSV + DH + DE)$

16. $SG = GR - (GA + GH + GE)$

17. $SF = EXP - IMP + NFI$

18. $EXP = EXPA + EXPN$

19. $IMP = MK + MR + MC$

20. $S = SP + SG + SF$

21. $S = I + SD$

22. $I = INA + INN$

23. $KA_t = KA_{t-1} + INA_t$

24. $KN_t = KN_{t-1} + INN_t$

25. $B = \sum_{i=15}^{45} ASBR_i * NPF_i$

26. $BF = 0.485 * B$

27. $BM = B - BF$

28. $NP = \sum_{i=0}^{75} NPM_i^{t-5} * SURM_i^t + \sum_{i=0}^{75} NPF_i^{t-5} * SURF_i^t$

29. $NPC = 0.7 * (\sum_{i=0}^{14} (NPM_i + NPF_i) + \sum_{i=65}^{75} (NPM_i + NPF_i))$

30. $NPS = \sum_{i=5}^{20} (NPM_i + NPF_i)$

31. $L = \sum_{i=15}^{65} NPM_i * LPM_i + \sum_{i-15}^{65} NPF_i * LPF_i$

32. $L = LA + LN$

33. $U = LA - RLA$

List of Variables for the Model

$ASBR_i$	age specific birth rate for all women in age group i + 5
B	number of births, thousands
BF	number of female births, thousands
BM	number of male births, thousands
CS	changes in stock, millions of 1966 NT$
D	depreciation of capital stock, millions of NT$
DA	depreciation of agricultural capital stock, millions of 1966 NT$
DC	purchase of clothing, millions of 1966 NT$
DE	purchase of education services, millions of 1966 NT$
DF	purchase of food, millions of 1966 NT$
DGDPA	GDPA per 1000 man years in agriculture, 1966 NT$
DGDPN	GDPN per 1000 nonagricultural workers, 1966 NT$
DPC	ratio of PC to PGC
DPF	ratio of PF to PGC
DPH	ratio of PH to PGC
DPSV	ratio of PSV to PGC
DH	purchase of health care, millions of 1966 NT$
*DM	dummy variable for change in business profit tax laws: 0 before 1960, 1 in 1961 and later
DN	depreciation for nonagriculture capital stock, millions of 1966 NT$
DSH	purchase of shelter, millions of 1966 NT$
DTDN	percentage of nonagricultural demand in total demand
DWA	inverse of DWN
DWN	ratio of nonagricultural wage rate to agricultural wage rate

DSV	purchase of services, millions of 1966 NT$
EXP	exports, millions of 1966 NT$
GDP	gross domestic product at market price, millions of 1966 NT$
GDPA	gross domestic product originating in the agricultural sector, millions of 1966 NT$
GDPN	gross domestic product originating in the nonagricultural sector, millions of 1966 NT$
*GA	government administrative expenditures, millions of 1966 NT$
*GE	government expenditures on education, millions of 1966 NT$
GH	government expenditures on health, millions of 1966 NT$
GIP	government income from property, millions of NT$
GR	government net revenue, millions of NT$
I	net investment, millions of 1966 NT$
IMP	imports, millions of 1966 NT$
INA	net investment in agricultural sector, millions of 1966 NT$
INN	net investment in nonagricultural sector, millions of 1966 NT$
*IPB	interest on the public debt, millions of NT$
IUD	cumulative percentage of married women who had a first IUD insertion in age group i + 5
*KA	capital stock in agricultural sector, millions of 1966 NT$
$*KN_i$	capital stock in nonagricultural sector with an embodied technological change of i percent per year, millions of 1966 NT$
L	total labor force, including armed forces, thousands
LA	agricultural labor force, thousands
LN	nonagricultural labor force, thousands
LNF_i	proportion of female labor force engaged in nonagricultural sector in age group i + 5

LNM_i proportion of male labor force engaged in nonagricultural sector in age group i + 5

LPF_i labor force participation rate for female in age group i + 5

LPM_i labor force participation rate for male in age group i + 5

*MC imports of consumer goods, millions of 1966 NT$

MD demand for money, millions of 1966 NT$

MK imports of capital goods, millions of 1966 NT$

MR imports of raw materials, millions of 1966 NT$

*NFI net factor income from abroad, millions of NT$

*NH number of households, thousands

NI national income, millions of NT$

NP total population, including military personnel, thousands

NPM_i male population at age i, thousands

NPC equivalent adult consuming population, thousands

NPF_i female population at age i, thousands

NPS school age population, thousands

P implicit GDP deflator, 1966 = 1.00

PA implicit deflator of GDPA, 1966 = 1.00

PC implicit deflator of consumer purchase of clothing, 1966 = 1.00

PCS implicit deflator of changes in stock, 1966 = 1.00

PDI personal disposable income, millions of 1966 NT$

PE implicit deflator of consumer purchases of educational services, 1966 = 1.00

PF implicit deflator of consumer purchases of food, 1966 = 1.00

PG implicit deflator of government purchases, 1966 = 1.00

PGC implicit deflator of private consumer purchases, 1966 = 1.00

PH implicit deflator of health care, 1966 = 1.00

PI	implicit deflator for fixed capital investment, 1966 = 1.00
PK_i	capital stock per worker, with an embodied technological change of i percent per year, thousands of 1966 NT$
PLN	proportion of labor force engaged in nonagriculture
*PM	price index of imports, 1966 = 1.00
PN	implicit deflator of GDPN, 1966 = 1.00
PR	nonagriculture profit, property, and rental income, millions of NT$
PSH	implicit deflator of consumer purchases of shelter, 1966 = 1.00
PSV	implicit deflator for consumer purchases of services, 1966 = 1.00
*PX	price index of exports, 1966 = 1.00
PY	personal income, millions of 1966 NT$
Q	market interest rate, percent per month
RLA	actual labor input in agricultural sector, thousands
t	trend, in years, beginning with unity in 1951
WA	wage and mixed income of farmers, NT$ per year
WBA	wage and mixed income bill of farmers, millions of NT$
WBN	wage bill of nonagricultural employees, millions of NT$
WN	wage rate of nonagricultural employees, NT$ per year
S	total saving, millions of 1966 NT$
*SD	statistical discrepancy
SF	balance of trade, millions of 1966 NT$
SG	government saving, millions of 1966 NT$
SP	private saving, millions of 1966 NT$
$SURF_i$	survival ratio for female population at age i
$SURM_i$	survival ratio for male population at age i

TD	total aggregate demand, millions of 1966 NT$
TDA	aggregate demand for agricultural goods, millions of 1966 NT$
TDN	aggregate demand for nonagricultural goods
*TFG	net transfer from foreign to government, millions of 1966 NT$
*TFH	net transfer from foreign to households, millions of 1966 NT$
*THG	net transfer from households to government, millions of NT$
TXB	business profit tax, millions of NT$
TXD	direct tax, millions of NT$
TXI	indirect tax, millions of NT$
XA	exports of agricultural goods, millions of 1966 NT$
SN	exports of nonagricultural goods, millions of 1966 NT$
U	disguised unemployment in agricultural sector, thousands
VDE	inverse of per capita spending on education, NP/(DE + GM)
VDH	inverse of per capita spending on health care, NP/(DH + GD)
VPDI	inverse of per capita disposable income
VPLN	inverse of proportion of nonagricultural labor force
VPK_i	inverse of PK_i

3. Discussion of the Equations

Judged by statistical criteria, the estimated coefficients of the equations are quite satisfactory. The dependent variables of the behavioral equations account for roughly 50 to 99 percent of the total variance in independent variables. The values of R^2 are all statistically significant. Most of the standard errors of estimate are small enough to give a value of t statistically significant at the 1 percent level. Almost all the signs of the individual regression coefficients are consistent to *a priori* expectations. Some of the Durbin-Watson coefficients,

as one would expect, are typically low.

In the following we shall examine some of the properties of the individual equations from the viewpoint of the whole theoretical model.

a. Production Functions The agricultural and nonagricultural production functions were estimated, respectively, by fitting real gross domestic product and labor and capital inputs for the period from 1951 to 1970 to the Cobb-Douglas form. The gross domestic products (at market prices) were taken from the latest revised figures in the national income statistics published by the Directorate-General of Budgets, Accounts and Statistics, Executive Yuan.

In measuring labor, input adjustments were made for level of utilization and for differences in composition and trends in economic and demographic characteristics of the labor force between sectors and over time. Statistical evidence shows that economically occupied persons in both manufacturing and service industries had worked, on the average, nine hours per day and twenty six days per month over the period under review.[2] Retail stores in Taiwan are open from morning to late evening for seven days a week. Persons -- employed, self-employed, or family helpers -- in practice, work or stand-by as long as the store is open. Quantitatively this amount of performance no doubt represents a full-time worker. We may, therefore, assume that the registered number of nonagricultural workers at the end of each year is equivalent to the number of man-years worked for that year. As noted in the preceding chapter underemployment in agriculture prevailed throughout the period. The registered number of workers on farms thus was substituted for the full-time equivalent employed, namely the actual man-years worked on farms in each year.[3] The ratios of man-years worked on farms to the

registered farmers represent the adjustment indexes of labor utilization. Part of the computed results are presented in column 1 of Table 4.1.

Tabulations of the labor force by age and sex, by employment status and education level for agricultural and nonagricultural sectors are available for 1956, and 1965 to 1970.[4] Based on these tabulations and a set of weights assumed for each category, three quality indexes were constructed to adjust man-years worked in each sector over the period. The product of these three indexes provides quality adjustment index for differences and changes in quality of man-years in the two sectors. The resulting indexes are presented in Table 4.1.

It is seen that in 1956 one observed unit of man-years worked by a farmer is equivalent to .56 efficiency unit (in terms of a male adult, paid employee with primary school education), while that by non-agricultural workers is about 1.04 (see columns 5 and 10 in Table 4.1). The ratio between these two represents relative efficiency in quality of man-years worked in the two sectors. For instance, in 1956 an observed unit of man-years worked in the nonagricultural sector is 87 percent more efficient than one in agriculture (see column 12 in Table 4.1). As some of the registered workers on farms were under-employed while industrial workers were not, e.g., in 1956 only 66 percent of farmers, on the average, worked 200 days that year (see column 1 in Table 4.1), the registered nonagricultural workers were 2.80 times more efficient than the registered farmers (column 11 in Table 4.1).

The relative efficiency had deteriorated for nonagricultural workers during the period from 1956 to 1970. A comparison of the utilization and components of quality adjustment indexes between the two sectors reveals the reasons immediately. First, the extent of

TABLE 4.1 ADJUSTMENT INDEXES FOR LEVEL OF UTILIZATION AND QUALITY OF LABOR IN AGRICULTURAL AND NONAGRICULTURAL SECTORS

year	Agriculture: Adjustment index[a] for					Nonagriculture: Adjustment index[a] for					Ratio of Nonagricultural workers to agricultural workers adjusted for	
	level of utilization	Quality: age sex[b]	Quality: employment status[c]	Quality: education[d]	total	level of utilization	Quality: age sex[b]	Quality: employment status[c]	Quality: education[d]	total	level of utilization and quality change	Quality change only
1956	.6650	.7802	.8578	.8314	.5564	1.0000	.8853	.9798	1.1964	1.0378	2.80	1.87
1965	.7219	.7654	.8203	.8957	.5624	1.0000	.8012	.9876	1.2157	.9619	2.37	1.71
1966	.7468	.7762	.8322	.9116	.5889	1.0000	.8035	.9916	1.2504	.9962	2.26	1.69
1967	.7939	.7497	.8142	.9174	.5600	1.0000	.7884	.9895	1.2624	.9848	2.21	1.76
1968	.8022	.7371	.8195	.9268	.5598	1.0000	.7789	.9864	1.2672	.9736	2.17	1.74
1969	.7650	.7419	.8241	.9392	.5742	1.0000	.7582	.9863	1.2768	.9548	2.17	1.66
1970	.8047	.7446	.8349	.9547	.5935	1.0000	.7578	.9857	1.2913	.9645	2.02	1.62

[a]The adjustment index is the ratio of the weighted sum of specific characteristics to the total observed number of employed workers.

[b]This series gives workers under 20 years of age and female workers 65 and over a weight equal to one-third that of an adult male, male workers 65 and over and adult female workers in the agricultural sector a weight of 50 percent of that of an adult male, and adult female workers in the nonagricultural sector a weight of 70 percent.

[c]This series gives employers a weight equal to 1.2 that of a paid employee, self-employed workers a weight of 1.1, and unpaid family workers a weight of .5 of that of a paid employee.

[d]The education weights are estimated on the basis of differential earnings between education groups in 1969 from an island-wide Economic Correlates of Fertility survey. The earnings and weights are as follows:

	No. of Cases (in persons)	Annual Average Income (1969 NT$)	Weight
No formal education	89	13,933	.62
Primary school graduates	537	22,528	1.00
Junior high school graduates	109	34,220	1.52
Senior high school graduates	140	40,507	1.80
College graduates	51	56,431	2.50

(Thanks are due to M. MacDonald for tabulating this information from the computer tape.)

SOURCES: Computed from data drawn from 1956 Population Censur Reports and from Quarterly Reports on the Labor Force Survey in Taiwan, Nos. 1-35.

agricultural labor utilization increased substantially. Second, the decrease in the age-sex adjustment index for nonagricultural workers was much greater than that of the agricultural because of the increasingly larger influx of young women into the service and manufacturing industries. Third, the educational quality of the labor force had improved at a more rapid rate of increase in the agricultural than in the nonagricultural sector. There are two main reasons: (1) the agricultural sector benefited more from the rapid expansion of the compulsory education program than the nonagricultural because it had a larger proportion of workers with no formal education, and (2) a large proportion of college graduates, ranging from 10 to 25 percent per year, who would have participated in nonagricultural production had gone abroad to pursue advanced studies and a great majority of them remained abroad after completion of their studies.[5] The resulting quality index for agricultural workers increased while that for nonagricultural decreased during the period from 1956 to 1970.

Due to the lack of detailed data for the years from 1951 to 1955 and 1957 to 1964, quality adjustment indexes for these years were estimated by extrapolating the 1956 to 1970 trends back to 1951 by a free hand graphic method. This series together with indexes of labor utilization was applied to annual data on registered labor of agricultural and nonagricultural workers, respectively, to obtain our economic and demographic adjusted labor inputs.

The value of capital stock for the agricultural sector, including land, farm housing, and fixed capital at the beginning of 1964, was published in the 1964 Agricultural Census.[6] The annual data on net fixed investment from 1951 through 1970 were obtained from the statistics

of national income accounts.[7] Based on these data the estimates of capital stock for 1951 to 1970 were made by converting the value of capital stock into 1966 constant prices and subtracting from or adding to the annual net investment.

Censuses of Commerce and Industry conducted in 1954, 1961, and 1966 provide the values of capital stock in the nonagricultural sector for the respective years. Evaluation studies, however, found that the capital stock was seriously underenumerated, partly due to difficulties in assessing the value of capital goods but mainly due to under-reporting by owners. A study to determine the accurate value of fixed assets at the beginning of 1966 was made by the Council for International Economic Cooperation and Development.[8] The estimate from this study is believed to be of better quality and therefore is used as a base for our calculations. Embodied technical progress was handled by building annual improvement factors into the gross investment series. These improvement factors were, respectively, zero, 0.5, 0.75, 1.00, 1.25, and 2.00 percent per year. The formula used for calculating technical embodied net investment is as follows,

$$NI = GI(1 + x)^{t} - D$$

where NI = net technical embodied investment in year t

GI = gross fixed investment in year t

x = rate of embodiment in capital formation

D = capital consumption.

This gives seven possible combinations of labor and capital inputs for the nonagricultural sector. Each of these seven was fitted into the Cobb-Douglas form.

The estimated parameters for the single agricultural production

function for Taiwan in the period from 1951 to 1970 are not unexpected. The positive output elasticity of labor input results from the use of economic, demographic, and utilization adjusted man-years worked in agriculture. If the number of persons engaged in agricultural activities had been used, the output elasticity of labor would have had to turn out negative, indicating the fact of underemployment. Relatively high output elasticity of capital is a reflection of the scarcity of natural resources. From the discussion in Chapter III we know that a 2.4 percent annual rate of neutral technical progress is quite consistent with the facts.

The seven estimated nonagricultural production functions show that as the rate of embodied technical progress for investment rises from zero to 2 percent per year the disembodied technical progress rate falls from 6.24 to 5.79 percent, and output elasticity of capital falls from 0.43 to 0.12. The magnitudes of those parameters are all within the reasonable range established by empirical findings from data for other countries.[9] Present knowledge about technical progress in developing countries is not sufficient to allow us to pinpoint an appropriate embodied rate. If we can assume that the nonagricultural sector in Taiwan did not deviate far from equilibrium conditions, then a production function with a 0.5 percent rate of embodied technical progress should be picked up to represent Taiwan's economy because this function gives values of marginal products of capital and labor closest to the actual returns to capital and labor (see Table 4.2). A comparison of the parameters of this selected production function and those of the U.S. economy as a whole in the period from 1929 to 1965 is as follows:

TABLE 4.2 COMPARISONS OF MARGINAL PRODUCTS OF CAPITAL AND LABOR AND THE ACTUAL RETURNS TO CAPITAL AND LABOR BETWEEN AGRICULTURAL AND NONAGRICULTURAL SECTORS

	1951	1955	1960	1965	1970
Agriculture					
Marginal product of labor (1966 NT$)	13,462	12,116	12,310	14,189	13,280
Marginal product of capital (%)	6.4	7.3	8.2	10.3	11.3
Nonagriculture					
Marginal product of labor (1966NT$) with					
KN_0	10,922	16,194	20,152	29,288	37,076
$KN_{0.5}$	13,675	20,276	25,232	36,671	46,422
$KN_{0.75}$	14,396	21,344	26,561	38,603	48,868
$KN_{1.0}$	15,156	22,473	27,965	40,643	51,450
Marginal product of capital (%) with					
KN_0	4.6	7.2	9.8	14.4	17.7
$KN_{0.5}$	3.1	4.9	6.8	10.2	12.7
$KN_{0.75}$	2.7	4.3	6.1	9.2	11.3
$KN_{1.0}$	2.3	3.7	5.2	7.9	9.8
Actual compensation of nonagricultural workers	10,760	15,364	17,490	25,400	31,039
Actual returns to capital	4.8	5.8	7.5	11.0	14.1

SOURCES: Marginal products were computed from the estimate of agricultural and nonagricultural production functions; actual rates are based on national income statistics.

	Taiwan	The U.S.[10]
Technical progress embodied in investment	0.5%	4.0%
Disembodied technical progress	6.0%	1.2%
Output elasticity of capital	0.288	0.170

If our assumption of Taiwan's nonagricultural sector in the vicinity of equilibrium conditions is valid, our results suggest that in contrast to the developed countries, the economic growth of the developing countries depends more on disembodied technical progress as a source than on technical progress embodied in investment. An important policy implication of this finding is that the import of machinery and equipment and foreign investment, as they occurred in the past, cannot be considered effective measures for accelerating technical advance. Awareness of this point has recently spread among businessmen in Southeast Asia. The general criticism of Japan's economic endeavor -- the mainstream of import and foreign investment in the region is:

> The Japanese frequently have signed up for a joint venture and then sent obsolete equipment from Tokyo in order to buy new equipment for the home factory. Another Southeast Asian complaint is that Japanese -- unlike the Americans or Europeans -- drag their feet on training local workers to take over jobs held by Japanese and often refuse to share their expertise with their business partners.[11]

The second implication, which follows from the first, is that indigenous organized research and fully trained professionals are needed to explore and adapt the appropriate technologies from abroad for the particular circumstances in the particular country.

Table 4.2 also shows the marginal products of labor and capital in the agricultural sector. It is impossible to compare these results

with the actual returns because the national income reports contain only statistics on compound farm income. A comparison of agricultural with nonagricultural marginal products and actual returns, however, is pertinent.

The marginal products of labor in agriculture and nonagriculture were almost the same in 1951. Thereafter the former remained stagnant while the latter increased rapidly from NT$ 13,675 in 1951 to NT$ 46,422 in 1970. Actual compensation of nonagricultural workers had also increased from NT$ 10,760 in 1951 to NT$ 31,039 in 1970. The rate of increase, however, was slower than that of the marginal product of labor. Since the measures of labor had been converted to comparable units -- equivalents of full-time male adult, paid employees with primary graduate education -- these findings show that the gains from shifting units of labor from agriculture to nonagriculture during the period from 1951 to 1970 had been increasingly enlarged. This result is partly supported by evidence from a survey of migrants to Taichung City in 1967, which found that about 48 percent of the migrants, most of whom were changing their occupation from farmer to nonfarmer, reported an increase in income since the year prior to their move, 43 percent reported no change, and only 8 percent a decrease in income.[12]

The marginal product of capital in the agricultural sector was twice as great as that in the nonagricultural sector in 1951. Differential rates of increase narrowed the gap gradually. By 1970 the latter exceeded the former by the significant margin of 1.4 percentage points. Explanations for these tendencies may be found in improvements in nonagricultural investment environments and in changes in the institutional arrangements of agricultural production. Before the implementation of land reform, investment in farmland was accessible to all

investors and it was safe and profitable. The profit came from both the sizable and increasing rent as well as from appreciation of land value. Rent, which took about half the produce of the land, increased from 1,821 kilograms of paddy rice per hectare in the period from 1914 to 1917 to 2,043 kilograms in 1938 to 1943. During the same period the price of a hectare of paddy field rose from 13,565 kilograms of paddy rice to 20,791 kilograms.[13] After land reform, farmland rent was pegged by law at 37.5 percent of the 1948 average yield from the land, hence the increase in productivity of land after 1948 goes to tenants or owner-cultivators rather than to landlords. At the same time the market price of tenanted land dropped by one-third to one-half of its previous value. Consequently, only tenants and owner-cultivators have had legal accessibility to and have benefited from investing in farmland. These special privileges indeed enhance their incentives to invest in land and land improvements. Investment in land, which is a kind of transfer payment, has no direct effects on land productivity. Investment in land improvements is relevant to marginal product of capital. Therefore, we shall look into its magnitude and nature to understand the trends of marginal product of capital in agriculture.

By law the size of landholding of each farm cannot exceed a maximum of 2.8 hectares of paddy field or the equivalent. In fact, due to the increasingly high population pressure on land the average size of farms had already decreased to 1.4 hectares in 1951 and in 1970 was only about one hectare. The smallness of farm size hinders the development of a modernized and mechanized agriculture and thus limits the agricultural capacities to absorb investments. At the same time small-scale cultivation also limits farmers' ability to accumulate capital.

In the first ten years after the implementation of land reform the ability to invest in land improvement was especially weak due to installment payments on land purchased from former landlords by most of the farmers. In addition the accessibility of modern financial markets to farmers was not fully developed. Under these special institutional conditions demand for and supply of private investment in agriculture, being isolated from the modern sector, equalibrated at a low magnitude. This small stream of investment over the period under review brought only an insignificant pressure on the diminishing returns from capital formation. Therefore, the increase in complementary inputs, especially in the labor force, and technical progress produced a counter force sufficient not only to overcome the diminishing returns from capital but also to raise productivity of capital in the agricultural sector.

b. Resource Allocation Equation From the above discussion of the marginal product of capital we found that perfect competitive conditions of the capital market were partially distorted by the enforcement of the land reform program. Therefore, irrespective of the fact that the marginal product of capital was higher in the agricultural sector than in the nonagricultural before 1965, the rate of capital accumulation in the nonagricultural sector was substantially greater (see Table 4.2). Capital market distortion had some beneficial impact on the economy because it diverted scarce resources to industries with great potential for development. Once the marginal product of capital in nonagriculture surpassed that in agriculture, as happened around 1965, this distortion would enhance the competing power of the nonagricultural against the trickle of investment in the agricultural sector. Lack of statistical data prevents us from a detailed quantitative analysis of the problem. Our

evidence on the sluggish increase in the rate of capital accumulation in agriculture in contrast to the rapid increase in nonagriculture lends support to this point.

As noted in Chapter III the implementation of land reform and use of labor-intensive technical innovations in the agricultural sector alleviated the underemployment problem in Taiwan by withholding a large part of the labor force. These measures were beneficial to development of both agriculture and nonagriculture as long as there was a rural labor surplus. In fact, only a few years after the beginning of economic growth, rates of labor absorption in both sectors were greater than the rate of increase in the labor supply. As a consequence, the surplus rural labor was gradually brought into effective use and the influence of the relative labor scarcity became increasingly great. The general influence of these agricultural policies on economic and population growth has been discussed in Chapter III. Here we shall concentrate on statistical analysis of their effects on labor allocation between sectors, that is, rural-urban migration and labor mobility problems in the field of population studies.

Our calculations in Table 4.2 show that (1) in 1951 marginal products of labor input employed in agriculture and nonagriculture were about the same; (2) in the process of economic growth agricultural labor productivity remained constant while that of nonagriculture tripled by 1970. The first part of our finding seems to agree with the actual situation of the developing countries in the initial phase of development. Research on labor productivity finds that industrial employees at this stage are characterized by low morale, lack of discipline, and high rates of absenteeism and turnover. As a result, their productivity is not likely to be better than that of their counterparts on farms. In

the case of Taiwan, conditions were slightly different. Colonial control and extension of primary education had corrected most of those deficiencies, but the same factors had also equally affected farmers' attitudes toward work. Therefore, no difference was found in labor productivity between the two sectors. This level of marginal product of labor was the result of a long period of economic stagnation. It may be looked at as a long-run equilibrium institutional rate of compensation to labor at which people are willing to render their services to production in either sector.

The explanation for the second part of our empirical findings may also be found in institutional distortion originating from land reform. Unlike capital, the effects of land reform on labor allocation are in favor of labor-intensive agricultural development. In the process of economic expansion during the period from 1951 to 1970 Taiwan's agricultural growth benefited from the accessibility of the source of surplus labor; in fact, it consisted of the farmers' own family members. Before the depletion of the surplus labor pool any increase in demand for labor could be readily met with a supply of labor at a constant institutional rate of compensation. For modern industrial expansion, however, the source of additional labor was not so conveniently located: it consisted of the rural surplus labor. Transfering from rural families to industrial employment generally involves a rise in real wages because of structural distortions. Reasons for structural distortions commonly found among other developing countries again are not fully applicable to Taiwan. For instance, government wage policies and trade unions in Taiwan had virtually no effect on the labor market. Throughout the period under review the minimum annual wage rate promulgated by the

government remained at NT$ 6,000 (at 1966 prices). This was less than half the lowest marginal product of labor in 1951, therefore it had no effect on wage determination. Trade unions in Taiwan also had no effect on wage rates for they never functioned in wage bargaining. Lack of accurate knowledge of job opportunities probably was a deterent to rural labor movement in Taiwan, for statistical evidence shows that in 1967 85 percent of the migrants to Taichung City received job information from friends and relatives and much of it was of a general nature.[14] Government and private employment services and modern mass media, however, were widely used toward the end of the period under study. Institutional distortions caused by land reform therefore remain the primary explanation.

Under the land reform system, (1) rent from tenanted land after the deduction of taxes was not profitable and had been becoming less so rapidly because it was fixed at 37.5 percent of the 1948 average yield, while taxes paid for owing land were assessed according to increasingly high land productivity; (2) tenantship is inheritable and cannot be terminated without the consent of tenants or their heirs; (3) farm land can be purchased only by those who are able to cultivate the land themselves, and the size of a holding shall not be more than 2.6 hectares of paddy field; and (4) farmland cannot be changed to other uses without government approval and without agreement between tenants and landlords if the land is leased. A cursory review of these arrangements show that tenants have enjoyed implicit subsidies for holding tenantship, while owner-cultivators bear losses if they choose to sell or lease their land. That is, farmers entitled to tenantship or ownership of land who intend to change their occupation will suffer a

substantial loss. The amount of this loss steadily increased during the period of study because land productivity and thus land tax increased. Consequently, the real wage level, i.e., the marginal product of labor, had to rise in order to attract rural surplus labor, in spite of the low and constant marginal product in agriculture.

As just noted, the labor market in Taiwan was not one of perfect competition. The distortion, however, did not seriously affect the validity of the labor demand curves derived from the agricultural and nonagricultural production functions. The functional relationship established by these demand for labor curves to determine labor allocation between the two sectors, i.e., equation (9) in Chapter II should still be applicable to Taiwan. In estimating this equation the proportion of nonagricultural workers had been broken down into age groups for each sex. The measure for the ratio of nonagricultural to agricultural wages was replaced by the ratio of nonagricultural wages to compound farm income per worker because agricultural wages were not given separately in the national income statistics. The output proportion ratio was also substituted with ratio of aggregate demand for nonagricultural product to agricultural product because the latter was closer to reality than the former.

From the estimated equations it is noted that except for the coefficient of wage ratio for proportion of nonagricultural male workers at age twenty to twenty-four, all signs of the coefficients are in agreement with the requirements specified on theoretical grounds. The only exception may reflect the fact that in spite of relatively high wage payments industrial employers strongly preferred to employ young male adults. On the whole the coefficients of the aggregate demand ratio are

more highly significant by a t test than are the coefficients of wage ratio. This finding is another support for our argument that the pattern of aggregate demand is a driving force in the determination of economic development and population growth.

c. Population Growth and Labor Supply Both longitudinal and areal demographic data are available in Taiwan for empirical analysis of the effects of economic development upon population growth and labor supply. To make them consistent with the nature of our long-run unemployment growth model and the available national income statistics, our estimated equations for the components of population growth and labor supply are the results of the longitudinal data for the period from 1951 to 1970. A common problem of applying the time-series technique to establish the long-run effects of economic factors on population changes is that the range of variation in characteristics and the degree of interaction among the explanatory variables in a twenty-year period may not be great enough to give accurate determinations of regression coefficients. There is, however, a series of excellent cross-section studies on population changes in Taiwan for this period which may be used to cross check our results.

FERTILITY FUNCTION For the purpose of eliminating the effects of differences in age and sex distribution of the population, age-specific birth rates for all women in Taiwan were used in the estimations. One important demographic factor, the proportion of married women, was not included because these data had not been made available before 1960. A preliminary regression analysis of the factor governing the proportion married from the published data from 1960 and on suggests that younger women are more sensitive to variables of educational

attainment and older women to level of economic development. Since these factors were also presented in the fertility equations, the effects of the proportion married had been implicitly taken into account.

All independent variables specified in our theoretical model had been regressed on the fertility of women in each of seven five-year age groups. However, due to the small number of observations and especially the lack of variation in fertility of women in the age groups fifteen to nineteen and twenty to twenty-four years old, the estimated regressions become unstable if more than three or four independent variables are used simultaneously in a single equation. Therefore, the regression results presented in our study are those equations with alternative combinations of three variables for age groups fifteen to nineteen and twenty to twenty-four and four principal variables for the remaining age groups. These variables are: technical progress τ_1, technical progress τ_2, productive capacity, income distribution, and economic structure. Technical progress τ_1 is measured by the cumulative number of married women who had a first intrauterine device (IUD) insertion in each five-year age group. Technical progress τ_2 is measured by per capita private and government spending on education. Productive capacity is measured by estimated capital per worker. Income distribution is represented by the ratio of the nonagricultural wage rate to the average compound income per farmer. Except for the variable of technical progress τ_1, the scatter diagrams of fertility and our independent variables show nonlinear relationships, therefore these variables were transformed into reciprocals.

Reviewing the results of regression equations for age-specific birth rates we find that the signs of coefficients for women at ages

thirty to forty-four are all in agreement with our expectations. The few exceptions, however, for women below thirty and beyond forty-five are likely to imply certain details in the process of family building rather than contradictions to our hypothesis.

The positive relation between the cumulative rates of IUD insertion and birth rates for women in age groups fifteen to nineteen and twenty to twenty-four years old suggests that young mothers tend to use contraception for spacing. This surmise is supported by data from individual couples. 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. Detailed tabulation of the 1970 survey also shows that a significant number of women were practicing family planning after having one child and the proportion increased rapidly as they were nearing their goals of having three or four children and one or two sons (see Table 4.3).

The positive sign of the coefficient of economic structure in the fertility regression function for women twenty five to twenty-nine, though the $\underline{t}$ test is insignificant, may suggest that due to the increasing tendency toward later marriage and the practice of spacing births (both were positively associated with changes in the economic structure from agricultural to nonagricultural), some births that would have occurred to women at younger ages had been postponed to women at ages twenty-five to twenty-nine. This surmise is based on the following facts. Between 1956 and 1970 the proportion of married women at fifteen to nineteen and twenty to twenty-four decreased respectively from 11.3 percent and 89.6 percent to 8 percent and 50.3 percent. This

TABLE 4.3 PERCENTAGE CURRENTLY USING CONTRACEPTION, CURRENTLY PREGNANT, AND MEAN LENGTH OF THE OPEN BIRTH INTERVAL, BY NUMBER OF LIVING CHILDREN AND NUMBER OF LIVING SONS, FOR WIVES AGED TWENTY-TWO TO TWENTY-NINE WITH ONE TO FOUR CHILDREN, TAIWAN: 1970

No. living children, no. living sons	(N)	Percent currently using contraception	Percent currently pregnant	Open birth interval[a] (months)
1 child				
0 sons	(36)	2.8	39.2	23.2
1 son	(31)	10.7	37.8	30.4
2 children				
0 sons	(67)	16.5	14.1	15.4
1 son	(145)	25.4	17.4	19.2
2 sons	(76)	31.8	12.4	24.2
3 children				
0 sons	(38)	11.6	18.8	10.9
1 son	(93)	26.7	14.4	18.8
2 sons	(116)	44.9	5.8	22.9
3 sons	(19)	30.9	5.2	16.2
4 children				
0 sons	(5)	43.9	0.0	8.3
1 son	(32)	18.5	6.2	15.0
2 sons	(39)	56.0	2.5	17.8
3+ sons	(42)	49.2	8.0	20.6

[a]For zero parity women, OBI = months married

SOURCE: Shanta Danaraj, "Son Preference in Taiwan," unpublished paper (Ann Arbor, Michigan: University of Michigan, 1973).

decrease, of course, reflects a trend toward marriage at a later age for women. In addition, by 1970 the length of the open interval, i.e., the average number of months since the last birth, for women of low parities was significantly longer than natural fertility would imply (see Table 4.3). As already noted in Chapter III fertility reduction in Taiwan was achieved mainly by regulating excess births while the traditional values of having three or four children with at least two sons remained intact. In the absence of deliberate birth spacing and with the low postwar mortality level a time span of six to eight childbearing years is needed to realize such traditional values. This time span implies that in 1951 most women who were married at the average age of twenty would achieve their fertility goals in their middle twenties. As the average age at marriage of girls and the practice of birth spacing among young married women increased, the time span for having the same traditional number of children gradually shifted and stretched toward women in older age groups.

A plausible explanation for the positive sign of the cumulative rate of IUD insertions in the regression equation for fertility at ages forty-five to forty-nine is that after controlling for all other variables, it is likely the higher the birth rate the stronger the motivations to limit the family size. The signs of the variables of productive capacity and income distribution coefficients for fertility at forty-five to forty-nine are also contradictory to our expectations. The reason for these may simply be that for the majority of women at very late reproductive ages who had achieved their familial goals, an increase in permanent or relative income would lead them to spend more on gratification from improving the quality of children already born,

rather than from having more babies.

On the whole, our results from the regression equations for age-specific birth rates tend to confirm our hypotheses about the relationships between fertility and economic development. They are also consistent with the findings of regression analyses of aggregate data for 361 local areas in Taiwan for 1961 and 1966 to 1969.[15] All of the areal analyses have observed a negative correlation between fertility and education, and the proportion of the male labor force in agriculture. It is worth noting that the finding of little correlation of fertility at ages twenty-five to twenty-nine with that at other ages in the areal analyses for 1966 to 1969 has the same implication as our finding of the positive sign for the coefficient of variable economic structure in the equation for fertility at ages twenty-five to twenty-nine in the time-series analyses.[16]

Our findings are also consistent with the cross-country results from studies of various countries made by Weintraub, Adelman, and Heer.[17] A fundamental difference, however, is that ours were based on observations from a homogeneous environment of Taiwan for a relatively short period and theirs were based on observations from countries with a vast variety of institutional and sociocultural backgrounds. Because of this difference our results tend to provide a more precise picture of the relations between fertility and economic development. These relations, however, are subject to the influence of environmental and historical factors of the particular economy in a particular time period. The factors with special significance for Taiwan are:

(1) Land reform program. In our discussion of resource allocation we have already found that the existing agrarian system had controlled

the flow of capital into and labor from the agricultural sector by imposing implicitly an opportunity cost on industrial employers. As land fragmentation continues and rural surplus labor diminishes this opportunity cost will rise. In consequence, the changes in the whole complex of variables in economic development will slow down and so the fertility decline will decrease, because of less rural labor moving to urban centers.

(2) Family planning program. An organized effort to reduce the birth rate through providing family planning services starting in 1964 was an important social intervention in the history of Taiwan's population. By 1970 about one-third of all married women aged twenty to forty-four, i.e., a cumulative total of 658,000, had had a first IUD insertion. As shown in our fertility regression equations, this organized effort had had an independent influence on reducing birth rates of women at ages thirty to forty-five and on spacing for women below thirty, even after controlling for all economic development variables. Since the purpose of the program is to make present knowledge and means of fertility regulation available to the general population rather than to change their attitudes toward fertility behavior, an increase in the number of IUD acceptors represents only that more women are able to achieve their ideal number of children or to avoid having more unwanted children. Therefore, if the family program continues to function as it has been, its influence on the birth rate will diminish when the number of women eligible for the program decreases.

(3) Desire for joint family living. In Taiwan the traditional family arrangement for parents to live with their married sons is still thought to be most desirable. An island-wide sample survey in 1965 revealed that 78 percent of wives aged twenty to twenty-nine expected

to live with their children in their old age, even if they have sufficient means to support themselves.[18] In 1970 a reinterview of their husbands indicated that only 10 percent of them do not expect to live with their grown-up sons and another 20 percent doubted if the circumstances would allow them to live with their married sons.[19] Insufficient development of satisfactory nonfamilial institutions for the aged, as reflected by the strong desire for joint family living, on the one hand, and the increasingly high uncertainty of fulfilling their desire under the foreseeable socioeconomic conditions on the other, is probably an important deterent to lowering the ideal number of children and therefore to further decline in the birth rate of Taiwan.

(4) Importance of male heirs. The traditional value given to having male heirs to carry on the family name and to continue the rite of ancestral worship are still prevalent and highly valued in present-day Taiwan. Eighty-three percent of married women aged twenty to twenty-nine interviewed in Taichung City in 1962 said that to have a male heir was very important; 13 percent rated it moderately important, and only 4 percent said it was unimportant.[20] Additional evidence on this point (see Table 4.4) indicates that in 1970 the percentage currently using contraception and the length of the open birth interval were significantly greater and the percentage currently pregnant was lower for married women aged twenty to twenty-nine who had achieved the ideal goal of having two sons than for those who had not.

These traditional values are so deeply rooted in the Chinese that even in communist China the use of most drastic measures, such as removal of family ancestor plaques from the lineage hall in each household, forbidding gatherings of lineage members, and so forth, could not

prevent people from honoring their ancestors and having a preference for having four children.[21]

MORTALITY FUNCTION Mortality statistics tabulated from the continuous population register of Taiwan have enjoyed a good reputation for completeness and accuracy for deaths of persons over five years of age. Tabulations of deaths of those under five have three main defects: underregistration and delay in reporting and misscount of ages for infant deaths.[22] These defects are serious but they can be and were corrected by use of the techniques of model life tables.[23] In our estimates the corrected survival ratios by sex and age for the years 1951 to 1970 were used to take the place of age-specific death rates, the main reason being that the survivor ratio can be readily applied to population projections.

In the period under review Taiwan benefited from the implementation of a low cost public health program. Therefore, an indicator of public health conditions -- the sum of real per capita expenditure on public health -- was included in the mortality functions. Since Taiwan's mortality rate in 1951 had already achieved a fairly low level -- only 11.5 deaths per 1000 population -- further decline was bound to be slower. A nonlinear form of reciprocal values of the explanatory variables is found to represent this tendency better than a linear form.

It is seen from the estimated functions for each five-year age group of both sexes that the regression coefficients of survival ratios with respect to the reciprocal of the total expenditures on health care are almost all negative (except 2 out of 32 cases) and statistically significant. The signs of the regression coefficients of the survival

ratios with respect to the reciprocal of per capita real disposable income tend to be positive for working age populations of either sex, and negative for younger and older persons. In general the coefficients are statistically significant. In brief, our regression results indicate a negative association between death rates and expenditures on health care for the population of both sexes at all ages, and a negative partial correlation between per capita real disposable income and death rates for population at younger and older ages, but a positive correlation for the working-age population.

These findings are consistent with our expectations but roughly speaking, they partially conflict with both Leibenstein's contention and Adelman's statistical findings of the relation between the rate of growth of real per capita income (ours is level of income instead) and mortality rates. Leibenstein advances a basic hypothesis in his economic population theory:

> The greater the rate of per capita income growth, the greater the rate of investment and, hence, the lower the level of consumption per unit of income. On the presumption that lower levels of consumption imply higher mortality rates, we arrive at the conclusion that the greater the rate of per capita income growth the less the rate of population growth, other things being equal.[24]

In a regression analysis of aggregate data for thirty-four countries during the period from 1947 to 1957, however, Adelman found a uniform negative correlation between the rate of growth of real per capita income and age-specific death rates. She explains that when the rate of growth of income increases, the relative share of income and thus consumption by the laboring population increases, therefore death rates diminish; while when the rate of economic expansion declines,

the share of profit increases at the expense of wage share, therefore leads to an increase in mortality.[25]

Table 4.4 presents the data of elements, which appeared in their arguments, on Taiwan for the period from 1951 to 1970. It is seen that Leibenstein's contention on the relation between income, investment, and consumption, to some extent confirms Taiwan's experience but his hypothesis about mortality and the rate of income growth does not. On the other hand, Adelman's hypothesis about the relation between rate of income growth and mortality agrees with what happened in Taiwan but her argument on the relation of the rate of income growth to wage share is weakly supported.

According to our analysis the explanation of the phenomena shown by the elements in Leibenstein and Adelman's arguments may be that the greater the rate of investment, the greater the rate of per capita income growth and, hence, the greater the level of consumption. In general, an increase in consumption level has favorable effects on lowering mortality, but as the consumption level rises beyond the level of basic nutritional requirements as that in present-day Taiwan did, its favorable effects tend to be offset by hazards owing to the rapid economic expansion for those in the labor force. The hazards commonly observed in this stage of development were long and exhausting hours of work, congested and insanitary working conditions, and occupational accidents.

LABOR FORCE PARTICIPATION EQUATIONS An important modification has been made in the estimation of the labor force participation equations -- that is, in order to eliminate the effect of changes in age and sex composition, age-specific participation rates rather than

TABLE 4.4 COMPARISON OF ECONOMIC VARIABLES AND MORTALITY LEVEL IN TAIWAN, 1951-1970

	1951 ∫ 1955	1956 ∫ 1960	1961 ∫ 1965	1966 ∫ 1970	Annual Rate of Growth 1951-55 ∫ 1956-60	1966-to ∫ 1961-65	1961-65 ∫ 1966-70
Per capita income (in 1966 NT$)	8,707	9,571	11,634	15,322	2.0	4.3	6.3
Rate of investment (in millions of 1966 NT$)	584	764	1,207	2,566	6.2	11.6	22.5
Per capita consumption (in 1966 NT$)	3,662	4,235	5,036	6,574	3.1	3.8	6.1
Average propensity to consume	0.42	0.44	0.43	0.43	-	-	-
Share of labor income in total income	0.65	0.68	0.68	0.69	1.1	-0.1	0.4
Average life expectancy at birth							
Male	57.5	60.9	63.3	64.7	1.2	0.8	0.4
Female	61.9	66.3	68.6	70.2	1.4	0.7	0.5

SOURCES: The same as for Table 3.13.

gross activity rate were used as dependent variables. This modification provides a rare opportunity to explore pure strength and direction of economic and social variables in determining the level of economic activities. However, due to the lack of such data prior to 1964 the number of independent variables in the regression equations have to be limited. In selecting independent variables for regression equations of age-specific participation rates various combinations of determinants suggested in our theoretical model had been tried. Among them the combination of capital stock per worker and economic structure indicator -- proportion of labor force engaged in nonagriculture -- gave the most reasonable and statistically satisfactory results for participation rates of male population of all ages and female population of forty-five and over; and the combination of capital stock per worker and age-specific birth rates gave reasonable results for women at childbearing ages.

A close look at the estimated equations reveals that our results support the hypothesis that, other things being equal, young and adult persons (those below sixty years of age) of both sexes, except women at ages twenty to twenty-nine with the heavy burden of child care, tend to be more willing to participate in economic activities when the productive capacity of the economy increases. The dependence of the labor supply upon the productive capacity, however, is much stronger (as indicated by t test) in women aged thirty to forty-nine than all others.

Our regression results also indicate the existence of a positive partial correlation between participation rate and economic structure indicator for populations of both sexes. United Nations studies have, however, found a negative partial correlation for male workers, but a

positive one for females.[26] A plausible explanation for this conflict is that in conducting the labor force surveys of Taiwan "potential labor force" defined as persons above fifteen years of age who were able but not willing to work, or not available to work during the survey week, had been explicitly explored so that there was a tendency to classify more persons into the category of potential labor force who would otherwise have been included in the labor force when the economy was relatively more dominated by agriculture.

The regression coefficients of the female participation rates upon respective age-specific fertility rates, except the one for the age group twenty to twenty-four which is discarded by t test, are all negative and statistically significant. These results, interpreted the other way around, are in accord with the findings of Mueller for Taiwan in 1968.[27] She found that "in Taiwan female labor force participation per se has practically no effect on family size goals. . . . contraceptive use is somewhat more frequent among working women than among others, and the incidence of pregnancies in the 28 months between surveys somewhat lower."[28] Since her study was concerned with the effect of female participation on fertility the actual level of fertility -- the number of living children -- was not used in the analysis in order to avoid inverse causation. From her findings, however, we may infer that there tends to be negative partial correlation between female participation and actual fertility level, and the causal relation runs from fertility to female labor participation.

d. Commodity and Money Markets

SAVING FUNCTION Saving function can be estimated by regressing total saving on its determinants specified in the model or by deriving

it from the difference between the estimated income and consumption equations. The latter provides more detailed information on how population pressures on resources affect the saving rate, therefore it was chosen in our study.

Household saving and business saving were combined into one category and denoted as private saving because in the period under review family enterprises dominated Taiwan's economy. Private saving, then, is the surplus of personal disposable income, including a negligible amount of undistributed profit, over private consumption. Personal disposable income, by definition, is the money value of the gross domestic product less depreciation, taxation, and transfer payments (for details see identities 7, 8, and 12). Gross domestic product is a function of the capital-employment ratio k, and hence the personal disposable income is also a function of k.

Consumption was divided into six main components: food, clothing, shelter, services, health, and education. Each component is assumed to be a function of personal disposable income, population, and relative prices (ratio of respective price to consumer price index). Changes in the age structure of the population affect the pattern of consumption through their impact upon age-connected needs and household consumption. In the demographic transition period, especially in the process of rapid fertility decline, changes in age structure are significant. To take these effects into account, different measurements of population were used in different consumption functions: equivalent adult consuming population in food consumption, number of households in spending on shelter, school age population in private and government education expenditure, and total population in the remaining categories of consumption.

Relative prices, an indicator of real cost to the economy, were added to represent population pressure on resources.

From the estimated euqations for the six components of consumption it is seen that, except for the regression coefficients of consumption of clothing and services upon population, the coefficients of consumption components upon disposable income and upon various population measurements are all positive and the coefficients upon relative prices are all negative. These findings are in agreement with economic theories and empirical results in other studies on aggregate consumption.

Explanation of the negative correlation between population and spending on clothing and services may be found in market conditions. Spending on clothing and services in general is for many luxury items, most of which can be provided either in the marketplace or in households. Other things being equal, an increase in population raises the demand of households on one hand and reduces per capita real income on the other. To cope with this stringent situation, consumers tend to cut down spending on these items either through real sacrifice or by substituting home-made goods and services.

The sum of the values of the coefficients of consumption components upon disposable income is the marginal propensity to consume. The income coefficients in our study, however, are the result of multivariate analysis and the variables other than income are all related to population. As a result, the sum of our income coefficients in fact represents the marginal propensity to increase consumption out of increment in disposable income already allocated to provide for consumption due to increase in population. The sum of all income coefficients is 0.645. If we let the lagged spending for education equal current

spending for education, we obtain a kind of long-run adjusted marginal propensity to consume, which turns out to be 0.695. The values of the marginal propensity to consume not adjusted for population effects for Taiwan and other countries in general fall in the range of 0.75 to 0.95.[29] In contrast to our findings it is clear that there exists a substantial population effect.

In order to show the relative importance of the influence of variations in income, population, and relative prices upon consumption patterns in Taiwan in the period from 1951 to 1970, the elasticities of demand for each component were calculated from the respective regression equations. These calculations, together with the income elasticities derived from the island-wide sample of families in 1966, are presented (in Table 4.5) in descending order of the values of our income elasticities. It is not surprising to find that the results derived from both the time series and cross section data for Taiwan are in accord with the general spending pattern -- that is, the income elasticities of demand for services, clothing, and education are higher than those for shelter, health, and food. The interesting points, however, are: (1) when allowances are made for increase in size of population and its pressure on resources, the difference in significance of income effect on varied consumption spending is greatly increased, (2) other things being equal, the relative importance of the population elasticities of demand for consumer goods tends to be in reverse order of income elasticities, and (3) the relative price elasticities fail to show a definite pattern.

Combining the six consumption functions and subtracting the sum from disposable income, we get the estimated private saving function

TABLE 4.5 INCOME, POPULATION, AND PRICE ELASTICITIES OF DEMAND FOR VARIOUS CONSUMPTION COMPONENTS

	Time Series Multivariate Result			Cross-section simple regression result, 1966
	Disposable Income	Population[a]	Relative Prices	
Services	2.80	-4.86	-1.96	1.53
Clothing	1.32	-1.02	-0.53	1.08
Education	1.31[b]	0.20	-	-
Shelter	1.00	0.14	-	1.06
Health	0.40	1.25	-3.38	0.80
Food	0.37	1.03	-1.30	0.81

[a]Population measurements for demand for services, clothing, and health care are total population size; for education, the size of the school-age population; for shelter, the number of households; and for food, the size of the equivalent adult consuming population.

[b]Calculated on the basis of the long-run marginal propensity for spending for education.

SOURCES: Time series multivariate results were computed from the regression equations of respective consumption components; cross-section simple regression results were adapted from Table 21 in "Report on the Survey of Family Income and Expenditure, 1966" compiled by Taiwan Provincial Government.

as follows:

$$SP = -63663.3745 + 0.3546PDI - 3.4283NPC + 1.9752NP - 0.1589NFS - 0.7588NH - 0.7752DE_{t-1} + 44760.0000DPF + 1495.6537DPC + 8647.7383DPSV + 10311.6875DPH$$

The direct influence of population growth upon saving can be read off immediately from the population coefficients. For example, an increase of one equivalent consuming adult will reduce private saving by the amount of NT$ 3,428 (US$ 85.50). Another population effect on saving is its influence upon relative price level. The percentage responsiveness of saving to food, clothing, service, and health, respectively, is 5.37, 0.21, 1.19, and 1.35. The high responsiveness to food price change perhaps indicates that the population growth effect via food prices carried a significant force restraining the extravagant ceremonial feasts like the prevailing "pai pai" parties. One important indirect population effect on saving which has been concealed in the process of aggregation is its influence upon the pattern of changes in consumption. As already noted, in contrast to rise in income, an increase in population tends to direct demand for the products of the industries of services and manufacturers to demand for primary (food) industry. Historical evidence from other countries and from Taiwan indicates that the tendency toward dependence on primary industry is not only an obstacle to economic expansion but also a deterent to modernization of population.[30] Consequently, saving must also be adversely affected by increase in population.

Saving in the government sector is defined as the surplus in current account (see identities 14 and 16). Except for transfer payments, which were treated as exogenous variables, various tax and

property incomes were respectively regressed on the variables representing the bearers or sources of the taxes. Fiscal policies were used by the government as the main strategies in the development of Taiwans' economy. The Statute for Encouragement of Investment was promulgated and carried out with significant impact on economic progress on one hand and on tax income from profit since 1960 on the other. A dummy variable to distinguish the existence of the impact on the latter (0 for 1951-1959 and 1 for 1960-1970) was incorporated in the business profit function. Changing the tax structure from reliance on indirect to direct taxes was also a vigorous government effort in tax reform. A time-trend variable was therefore introduced into the indirect tax function.

All the regression coefficients in the government revenue functions are in agreement with our expectations and are statistically significant. It is interesting to note that the negative association between revenue from direct taxes and the compound farm income reflects part of the government agricultural policies.

Health expenditures is a function of government revenue and population, while all other expenditures are treated as exogenously determined. The regression result of health expenditures suggests that population was an important determinant in allocation of government resources.

The sum of the functions of private saving, government saving, and the exogenous variables equals the total saving function. In practice, the total saving derived from the aggregated saving function can be taken as equal to investment. On the theoretical ground, however, we need an investment function to complete the subsystem of the commodity market. Due to the lack of detailed data on investment it is

impossible to make an elaborate analysis for investment comparable to that for saving. Using the aggregated investment data, however, we obtain a statistically significant negative correlation between investment and the market interest rate, and a partial positive correlation between investment and capital per worker. These results are all in accord with a priori expectations, therefore we may also believe that the underlying relations are likely to be consistent with our speculations developed in the theoretical model.

LIQUIDITY PREFERENCE FUNCTION The liquidity preference function for Taiwan in the developmental period was estimated in accordance with the formulation given in the theoretical model -- that is, the demand for a real cash balance is a function of the capital-employment ratio and market interest rate. The amount of the real cash balance for the period from 1951 to 1970 is the sum of currency in circulation and demand deposit, divided by the implicit GDP deflator. The interest rate charged by private money lenders is used because in Taiwan the bank interest rate was controlled by monetary authorities.

It is noted that the coefficients of both the interest variable and capital-employment ratio have signs in agreement with our expectations. These findings are also consistent with the results of a study on demand for money in Taiwan during the period from 1951 to 1968 where the real private wealth was used in lieu of the capital-employment ratio.[31]

MONEY WAGE AND PRICE EQUATIONS The main purpose of including money wage and price equations in our empirical model is to incorporate into our system as an integrating part the relative prices which were used as indicators of population pressure on resources. Money wage rates of agricultural and nonagricultural labor are assumed to adjust to

the cost of living and the state of demand in the labor market. The cost of living is measured by the deflator of private consumer purchases. The state of labor demand is represented by the level of labor productivity, i.e., gross domestic product per worker of the respective sector and the general level of unemployment. Price of gross domestic product in the agricultural and nonagricultural sectors and prices of the components of aggregate demand are considered to be set in terms of wages and other costs -- that is, to be marked up over costs. Prices of exports and imports are assumed to be exogenous.

On the whole, the signs of estimated coefficients in wage and price equations are mostly in agreement with our expectations and the coefficients are statistically significant. Detailed discussion of the wage and price level is beyond the scope of this study. However, a few interesting points revealed in the money determination equations probably deserve brief mention. The comparison of elasticities with respect to the three independent variables between agricultural and nonagricultural sectors are calculated as follows:

	Agriculture	Nonagriculture
Consumer price level	0.72	0.11
GDP per worker	1.99	1.63
Disguised unemployment	-0.95	-0.07

It is seen that average labor productivity is almost equally important in determining the money wage rate in both sectors, while the level of consumer prices and rate of disguised unemployment are only relatively influential in determining the agricultural wage rate. The implications of these findings are: (1) other things being equal, wage

differences between the two sectors are largely caused by the differential growth rate of average productivity, (2) since the overwhelming majority of farmers were self-employed and the greatest portion of nonagricultural workers were wage earners, the "labor cost push" inflationary tendency was rather weak in Taiwan, and (3) a reduction in disguised unemployment benefited farmers through a rise in average wage per worker (not per-man-year employed) more than workers in the nonagricultural sector. All of these results are consistent with our discussion on resource allocation.

e. Foreign Sector and Identities

FOREIGN SECTOR In empirical tests of our theoretical model the foreign sector added to fit the real situation in Taiwan. Imports were divided into three categories: capital goods, industrial raw material, and consumption goods; and exports were divided into two: agricultural products and manufacturing goods. The import of capital goods is a function of investment and import of raw material is a function of the gross domestic product of the nonagricultural sector and the export of manufactured goods. The estimated regression coefficients for these functions are all statistically significant and have signs in accord with our expectations.

Although the ratio of exports to gross domestic product increased steadily from 10.2 percent in 1951 to 30.6 percent in 1970, the share of Taiwanese sales abroad in the world market was still relatively insignificant. From preliminary two-stage least-square regression of Taiwan's exports on the variables of world economic activity, world relative price, and lagged exports, it was found that the highest coefficients of determination and most consistent regression coefficients were obtained

from the regression of exports on the lagged exports. Therefore we may infer that world economic activity and relative price have little influence upon the value of exports. The main determinant is likely to be the ability to export, which is best represented by total exports in the previous year.

IDENTITIES So far we have completed the discussion of the behavior equations in our model. The behavior equations cannot be connected, however, without some identities. There are 34 identities in our model. Identities (1) through (22) relate national product to national income -- that is, the definitional relations between output, expenditures, and income. Identities (23) through (24) represent the capital accumulation process. Identities (25) through (34) concern definitional relations between vital rates, population, and labor force. Since all the identities simply redefine some variable in a straightforward manner, they do not require further explanation.

Footnotes

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CHAPTER V. SUMMARY AND CONCLUSIONS

The purpose of this study is to provide a theoretical framework for an empirical analysis of the interactions between population growth and economic development in Taiwan. To do so a neoclassical growth model is extended in a number of ways to take into account the specific features of an economic-demographic model and the significant characteristics pertinent to developing countries like Taiwan. First of all, population is treated as an endogenous variable in the system. Second, the one-sector model is disaggregated into a two-sector model by way of combining the agricultural and nonagricultural production functions into a single aggregate production function without losing their respective identities. Third, the standard assumption that the labor force increases at a constant rate of exogenous population growth is replaced by the hypothesis that the rate of employment and the wage rate are simultaneously determined in the labor market, and rural unemployment or underemployment is identified by the difference between man-years worked and actual number of persons engaged in agriculture. Fourth, instead of assuming that saving automatically equals investment, the rate of investment is assumed to be simultaneously determined by forces in the capital and money markets.

Population enters the extended two-sector growth model via its influence upon the two key inputs into the productive process: labor and capital. Changes in the quantity and quality of these two inputs,

together with technical progress, determine the level of national product. Given the socially acceptable wage-rental ratio, the allocation of labor and capital between agricultural and nonagricultural sectors is uniquely determined under the conditions: (1) total usage equals total availability, and (2) the value of the marginal physical product of each input is equal between the sectors.

Social, cultural, and institutional factors are included in our model because they are the main forces that determine the organization of the economic system. More explicitly, these factors specify the institutional "rules of the game" under which population behavior is observed and the economy operates. Due to difficulties in quantifying these variables we treat them in two different fashions: (1) the relevant institutional variables that varied within the period under study were included in the model by use of the dummy variable regression technique, and (2) those that did not vary during the period were analyzed against the historical background.

1. Summary of Major Findings and Policy Implications

Some of the main findings of the empirical study may be summarized in three brief propositions:

(1) Institutional factors have significant influences upon the relationships between population growth and economic development. Findings supporting this proposition are:

(a) State control over international exchange relations was found to be a dominating factor in shaping the course of economic development and population growth in Taiwan. In Chapter III it was demonstrated that the formulation and execution of the policy to develop

Taiwan as a supplier of agricultural products for Japanese industrial development during the period from 1895 to 1945 brought remarkable growth in farm production as well as fostering rapid population growth, via its effect on the pattern of labor participation. In contrast, the implementation of policies of import substitution and export diversification in the postwar period led Taiwan's economy toward industrialization and engendered influences in favor of fertility decline.

(b) Policies guiding income distribution and expenditures had the same ultimate effect as the control of international exchange relations for the two periods. During the colonial period, the greatest portion of income originating from economic progress was reaped by the government and a few Japanese nationals, while the indigenous population enjoyed only a small part of it. Because of this, per capita income increased relatively slowly in comparison with productivity improvements. The small increment in income only enabled the general population to have more preferred primary products in its home market. At the same time, equipment and industrial materials were almost all supplied by Japanese firms. As a consequence, the regulated domestic demand was predominately agricultural, and hence had the same effects on economic and population changes as the policies that developed Taiwan as a supplier of farm produce. After the war the determination of income distribution and expenditure was, to a great extent, restored to the play of market forces. The interactions between population growth and economic development in this period were largely free from institutional interference in these respects.

(c) The effects of the agrarian system on many aspects of economic-demographic relations have been demonstrated. Some were

favorable, some unfavorable, depending mainly on the stage of economic development. Under the Japanese occupation the traditional Chinese tenancy system was preserved for the sake of maintaining social order. Since landholding at that time served only a property function, landlords, except for their social and political functions, played no active roles that contributed to agricultural growth. On the contrary, the maintenance of the traditional peasant society was an obstacle to the modernization of Taiwan's population. After the land reform in the early 1950s, landlords of the old system were channelled from their inactive roles to enterprising pursuits outside farms, and the cultivator-owners under the new system had high incentives to improve land productivity. From an economic point of view, in this first stage land reform was beneficial to equality of income distribution and the development of agriculture and nonagriculture when the densely populated economy of Taiwan began its progress from its initial phase of development toward industrialization. But later, when the economy attained a certain degree of industrialization, the small holdings advocated in land reform gradually turned out to be a bottleneck to further development -- in the double sense of holding large numbers of the labor force on farms and of preventing mechanization of agriculture.

It is likely that land reform had important demographic effects. It seems probable that land reform with its incentives to the individual farmer introduced him to the idea of economic calculation. This stress on rationality may have helped in the relatively rapid adoption of contraception in the rural sector, especially in the late 1960s. However, since the individual farmer still had incentives to have sons both to work on the farm and to inherit it, the traditional stress

on having three or four children and one or two sons continued. Therefore, the fertility decline was mainly preventing unwanted births above this number, but the ideal number of children and sons fell very little. Therefore, it is likely that the very rapid adoption of contraception had less effect on fertility decline than would have occurred if the institutional factors had not continued to support the value of children and sons. This is a point of some importance, because it indicates that the very successful Taiwan land reform program in its initial stages had mainly beneficial effects: in its later stages, however, the continuing stress on improving output by intensive cultivation had an undesirable restraint both on agricultural efficiency and on the potential fertility decline.

(d) Social and cultural factors played a more important role in determining the ideal number of children for Taiwanese couples than in affecting economic development. However, the sustained rapid economic growth for the past seventy years in Taiwan might, at the least, indicate the lack of force of traditional Confucian thought which involved a low valuation for economic incentives, material rewards, and rational calculations. If such values existed in Taiwan, they obviously did not constitute a major obstacle to economic development. But the reasons for the persistence of the preference for four children with at least two sons even amidst rapid economic progress were found to be explained mainly by traditional familial values: desire for joint family living and importance of male heirs in the context of the small cultivator-owner system with intensive agriculture.

(2) <u>Given the sociocultural and institutional milieu, interactions between population growth and economic development in Taiwan are</u>

extensive. Empirical findings from the application of the economic-demographic model to the Taiwan data for the period from 1951 to 1970 can be summarized as follows:

(a) The response of population growth to economic development. The primary influence of economic development on population growth was observed in the regression equations of fertility, mortality, labor distribution (proportion of persons engaged in nonagriculture), and the labor force participation rate in our system. A major finding for fertility is that economic factors -- capital per worker (a proxy of permanent income), proportion of labor force engaged in nonagriculture, and ratio of agricultural to nonagricultural wage -- have a significant bearing on the fertility of women over thirty years of age. Younger women did not respond as sensitively to these economic changes, mainly because they were in the process of achieving their socioculturally determined family size goal. Increase in spending on health care had a favorable effect on mortality decline at all ages. When this factor was controlled, however, the commonly observed favorable effect of increase in level of per capita income showed up for mortality decline for young and old persons but not for adults. A plausible explanation for this is that the adults might earn their incomes at the expense of their health during periods of rapid economic growth.

Unlike most of the rural-urban migration studies, our model approached this problem from the side of labor allocation between agriculture and nonagriculture. An interesting finding from postwar Taiwan's experience is that the proportion of labor force employed in the nonagricultural sector is strongly and positively correlated with the changes in pattern of aggregate demand from agricultural to

nonagricultural products, but tends to be negatively correlated with the ratio of nonagricultural wage rate to the per-farm-worker mixed income (a proxy of the urban-rural differential). The latter portion of the result seems to be contradictory to the rationale and empirical findings of internal migration because there it is proved that the positive difference between urban and rural wage is the main pulling force causing the redistribution of workers from farm to nonfarm. Both findings are valid, because ours tells how the market wage reacts to a given stock of nonagricultural labor, while migration studies are concerned with the determination of migration flows.

Another salient point derived from this approach is that although differences in composition by age, sex, educational level, and employment status had already been eliminated, due to the institutional distortion in the labor market caused by the land reform regulations, rural-urban wage differentials emerged after 1951. In addition, despite the flow of labor from rural to urban areas, this wage gap has widened over time. Our regression analysis also shows a strong positive relation of labor force participation rates for each age and sex group to the amount of capital per worker and the proportion of workers engaged in the nonagricultural sector. This finding supports the assertion that the total size of the economically active population and its age and sex composition are not only determined by the size and composition of the population but also by economic development.

(b) The response of economic development to population growth. The direct influence of population growth on economic development arises primarily from two effects: changes in the size of the population and changes in its age and sex composition. In our model the

composition effect was handled by using population measures that are free from the effects of age and sex -- that is, equivalent adult consumers and school-age population. Changes in the population size in Taiwan during the period from 1951 to 1970 were found to have a strong influence on the pattern as well as on the aggregate volume of consumption. A most interesting result is that after being controlled for income and price, demand for services and clothing is negatively related to population increase, and the population elasticities of demand for various consumption categories rank in reverse order from those for income elasticities. That is, from large positive values to small negative values in this order: health, food, education, shelter, clothing, and services.

The influence of population changes on domestic product operates through effects on employment in the agricultural and nonagricultural production functions. Employment in our model is not taken as a fixed proportion of population, but is determined by supply and demand in the labor market. After a time-lag of fifteen years or more, population growth (through the balance of births and deaths) does not necessarily correspond to an increase in employment and therefore, irrespective of the assumption of constant return to scale in the estimation of production functions, an increase in population does not always imply a rise in domestic product.

Another salient finding is that when the variables of price and labor productivity in both sectors are held constant, a one percent increase in the number of disguised unemployed agricultural workers will lower the farm money mixed income by 0.95 percent while lowering the nonagricultural wage rate by only 0.07 percent. This finding

implies that, other things being equal, an increase in the rate of disguised unemployment will widen the wage gap between agricultural and nonagricultural workers.

(c) The interaction between population growth and economic development. Having obtained the unidirectional relations of population growth to economic development and vice versa from the statistical data for Taiwan for the period from 1951 to 1970, we may proceed to examine mutual interactions by linking these unidirectional relations together with other behavioral equations and identities specified in our model. The brief sequence of interconnections is as follows: as the level and pattern of aggregate demand at home and abroad change, the extent and structure of economic activities (labor participation rates and proportions of labor engaged in nonagriculture) will adjust accordingly. These responses exert influence on population growth, mainly through fertility. Again, the changes in size of the population affect the level and pattern of aggregate demand.

(3) Some of the economic and sociocultural institutions conducive to economic development and population modernization did not improve at the time they were needed and as a result the interactions between population growth and economic development were restricted. The relevant rigid institutions are:

(a) The land reform system. After the completion of land reform in 1953 the laws and regulations were strictly observed without basic change. The latest revision, for instance, was that in 1973 the privilege of obtaining government loans to purchase land up to three hectares was extended beyond those farmers owning less than two hectares of paddy field to those owning less than three hectares. Thus the emphasis

on intensive agriculture, which was beneficial in the first stages of land reform, probably had negative effects in the later stages: holding labor on family farms for intensive labor inputs, retarding mechanization and possible combination of small units into more efficient larger units by cooperatives or other means, and, as indicated earlier, probably retarding potential fertility decline.

(b) The family planning program. Taiwan's family planning program succeeded in spreading the knowledge and means of fertility control to the general population. The program, however, did not actively seek to spread modern ideas about family size. It is unknown to what extent more emphasis on changing values would have been successful.

(c) Services for the elderly. Insufficient development of services for the elderly outside the family circle was reflected in strong preferences by the elderly to live with married sons. Financial arrangements for the aged were not well institutionalized. Convenience and an atmosphere favorable to noneconomic self-reliance of parents were found to be of great importance, but little attention or action was directed to these aspects.

(d) The cultural climate. The traditional values requiring male heirs to carry on the family name and to continue the rites of ancestor worship were found even among the population in urban centers. The values seem to be prevalent and persistent.

In sum, from our regression results it was observed that the land reform regulations and labor-intensive cultivation policy resulted in the use of increasingly large amounts of labor in the rural sector. As long as a rural surplus labor force was abundant, there was no

competition for labor between the agricultural and nonagricultural sectors and both benefited, but after a decade of rapid economic growth labor gradually became a scarce factor relative to capital. This change first retarded the flow of labor to the industrial sector and then increased the rate of population growth through reducing the rate of decline in fertility. Furthermore, the incapacity to improve social and cultural institutions as mentioned above placed a lower limit to fertility decline -- that is, the ideal goal of four children with at least two sons. Other things being equal, a relatively higher rate of population growth implies a greater demand for primary products relative to secondary and tertiary products, and hence more of the labor force is withheld on the farm. The cycle of interactions between population growth and economic development is complete. It is worth noting once more that the cycle is a "vicious" cycle if the institutional factors are not improved at the time they are needed.

An important implication of our propositions is that since population growth and economic development are closely interrelated and they are only parts of the integrated sociocultural and economic growth process, the soundness of any particular development policy will largely depend on whether and to what extent the relevant relationships have been taken into account in formulating it. The important measures to accelerate agricultural development announced by Premier Chiang in 1972 may serve as an illustration.[1] The purpose of these measures is to alleviate the grievance of the disparity in income distribution between farmers and nonfarmers caused by differentials in growth rates of productivity. The measures for attaining this include: abolition of the surtax on land and of the implicit burdens on farmers

imposed by the system of exchange of government-supplied chemical fertilizers for farmers' paddy rice; provision of favorable agricultural credit; construction of subsidiary roads, dams, and irrigation facilities; improvement of the agricultural marketing system; encouragement of agricultural specialization and the spread of plants and factories to rural areas; promotion and strengthening agricultural research and extension services; and promotion of agricultural mechanization and cooperative farming. To implement these measures the government has appropriated a total amount of NT$ 2,000 million (US$ 50 million) for 1973 - 1974 -- the equivalent of one-fifth of the 1970 agricultural gross investment for each year. Obviously, as all these measures are direct subsidies to farmers, they surely will bring an immediate increase in farm incomes. This is the policy target desired. However, judging by our findings of the conditions and mechanisms under which the economy of Taiwan operates, the most efficient measure would be the promotion of agricultural mechanization and cooperative farming -- for this would lead to a relaxation of the constraints imposed by the land reform regulations.

2. Evaluation and Suggestions for Future Research

The present study might be refined or extended in a number of ways. First of all, although the parameters were estimated by using the statistical data for the postwar period, the model has not actually solved for the endogenous variables of the system in terms of the exogenous variables and policy variables. That would be a useful exercise and should provide some quantitative results for evaluating policy measures. Since our model contains several nonlinear variables, a complicated computer program would be needed. Neither time nor means

have allowed us to do that for the present study. However, a conventional exercise of assuming alternative population trends to trace the effects of population on economic development is not suggested because we have 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.

The main body of our statistical analysis was based on empirical data for Taiwan over a relatively short period. The estimated coefficents are thus socioculturally and institutionally bound. For conclusions of general validity to be drawn from this kind of time-series approach we should complete and compare similar analyses for several other countries.

Another limitation of the time-series approach is that the range of variation in characteristics over a short period is small and the intercorrelation among the explanatory variables is great. As a result, the accuracy of the estimated regression coefficients, especially those with more variables, has been seriously affected. In preliminary estimation of the behavioral equations we experimented with a variety of combinations of variables in order to obtain the most reasonable results. To avoid this statistical problem, an alternative would be the use of aggregate area data at the same time. This kind of study could be conducted for Taiwan for the geographical units either of 21 hsien (county) and city levels or of 361 local administrative area levels without much difficulty, for all of the demographic and some of the economic data are already collected and published for each year since 1961.

Footnote

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