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URBANA, ILLINOIS 61801

CAC Document No. 80

THE LIMITS OF JAPANESE GROWTH: AN ECONOMETRIC STUDY

by

Kimio Uno

1973

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KIMIO UNO

B.A., Keio University, 1963
M.A., Keio University, 1969

THESIS

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics in the Graduate College of the University of Illinois at Urbana-Champaign, 1973

Urbana, Illinois

THE LIMITS OF JAPANESE GROWTH: AN ECONOMETRIC STUDY

Kimio Uno, Ph.D.
Department of Economics
University of Illinois at Urbana-Champaign, 1973

This is a prototype econometric model aimed at revealing possible limits of economic growth, taking empirical data from the Japenese experience from 1950 to 1970.

The limits may arise from availability of factors of production. Equally important constraints on continued growth, however, are imposed by the public recognition of other values which have too often been ignored in the past. Recent attempts to deal with "non-economic" variables in addition to "economic" variables resulted in recent attempts to develop welfare indicators or social indicators. At the present time a general economic model capable of integrating what has been considered "non-economic" factors and more conventional economic factors is not available. This dichotomy is not warranted since "non-economic" factors have increasingly exerted their influence on economic factors.

In light of the seriousness of this lack of knowledge, the aim of this dissertation is to provide a theoretical and empirical framework for study of these problems which explicitly recognizes the inter-relationships. The model is developed covering environmental indicators including input of environment to economic activities and output of pollutants; population status indicators including health, accident rates, crime rate, and hours of work; material benefit indicators including the use of the stock of consumer durables, housing capital, and social capital; density indicators, and speed of social transformation

indicators. These variables are integrated into a macro-economic model having primary and non-primary sectors, saving and investment functions, consumption functions, price equations, and export and import functions. It is a combination of an economic development model and a system of social indicators.

The model has 74 equations, all of which are specified in linear forms. Individual equations are estimated, tested, and reduced form coefficients are obtained. Finally, the simulation of the model for the 1950-1970 sample period and projection for 1985 is provided.

The relevance of the study to many of the problems plaguing Japanese society is considerable, since in Japan there is increasing concern over "non-economic" factors brought about by "economic" activity. They include environmental pollution, threatening exhaustion of natural resources, limited availability of land and water, increasing traffic injuries, frustration caused by high density of economic activity, growing preference for leisure, maintaining technological progress, militarism, and rising prices.

The concern can be formulated into a set of rational and consistent policy measures only when the interrelationships of the set of problems are explicitly recognized. The formulation presented in this study will provide theoretical and empirical content to an extended economic system, and is expected to serve as the basis for consistent policy decisions.

ACKNOWLEDGMENT

I would like to express my sincere gratitude to the members of my dissertation committee, Professors Hugh Folk, Koji Taira, Alan Duchan, and Rene Vandendries who have given me continual intellectual stimulus and encouragement throughout the preparation of this thesis. I would like also to thank Professors Kenzo Kiga, Hiroshi Kato, and Naomi Maruo for guiding me to the recognition of wider implications of economic activities. I am indebted to Barbara Knuckles for editorial help.

As always, my greatest debt is to my wife, Noriko.

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CHAPTER 1

THE OBJECTIVES AND SCOPE OF THE STUDY

1.1 New Problems

This research presents a prototype econometric model aimed at identifying possible limits of economic growth, taking empirical data from the Japanese experience from 1950 to 1970.

Economists have been concerned with economic output as the single or major measure of growth. The task of economic analysis must become more inclusive as the public recognizes other values which have too often been ignored in the past.

A dichotomy between economic and non-economic relations is common in the study of economics. Economists have been aware of various aspects of non-economic factors which cannot be measured in monetary terms, and yet which contribute to the improvement of welfare level. However, economists usually confine their analysis to economic relations, i.e., all those entering the production cycle as factors of production. The exclusion of what has traditionally been viewed as non-economic relations threatens the relevance of economics for today's society in which components of welfare which are not necessarily reflected in the changes in national income are increasingly important. The accumulation of capital and economic development has brought about affluence to the leading industrial societies in the United States, Japan, and Western Europe; the level of economic welfare has increased so much that most economic wants are satisfied or on the verge of being satisfied in the near future. It is therefore increasingly necessary to take the non-economic welfare into consideration in economic policy decisions.

Confining attention to national income to the neglect of non-economic welfare is no longer warranted.

In Japan, real GNP has increased sevenfold in the past two decades and per capita output of some major industrial products now surpasses the U.S. level.[1] In spite of this apparent success, a survey by the Japanese government in 1971 reveals that nearly 50 percent of the people feel that economic growth made them neither better off nor worse off, bringing about hardships as well as benefits. Only 27 percent of the people think that the growth was beneficial, while 18 percent of the people actually feel that it did more harm than good.[2] The Japanese people think that from now on the effort should be directed at the prevention of pollution and the provision of social facilities rather than at an increase in output. Only 6 percent of the people think that the increase in output is important, whereas 42 percent think that the pollution prevention is of prime urgency, and 33 percent think that provision of social capital the most important.[3]

This tendency is shared by many other societies, but may be greatest in Japan because, first, the lack of space (an area equal to 3.8 percent of that of the U.S., of which only 20 percent is habitable) relative to the size of the population (50 percent of the U.S.) and the level of industrial activity contained in it.[4] Another reason is the continued rapid economic growth, with accompanying rapid structural changes.[5]

The Japanese seem to have failed to turn economic success into human happiness. The contradiction of growth as witnessed by the success in terms of conventional indicators which is disapproved by the public indicates that some important variables are left out of the conventional analytical framework.

The limits to growth may arise from limited availability of factors of production. Equally important constraints, however, may be imposed by the public recognition of other values which have been left out of the scope of economics.

The new problems, not traditionally dealt with within the framework of economics, require a new point of departure in treating them.[6] In fact, they do not fall under any one particular discipline. What makes the matter more complex is the fact that these problems are interwoven and form a large set of problems which must be dealt with simultaneously. These problems include environmental pollution, threatening exhaustion of natural resources and available land and water, increasing traffic injuries, frustration caused by artificial environment and high density of economic activity, various frictions accompanying rapid social change, growing preference for leisure, and increasing desire to attain higher educational level as well as the related problem of labor force participation. Some of the conventional problems require new approaches. Rising prices, agricultural policy of self sufficiency, trade surplus, maintaining technological progress, militarism and prestige-seeking projects can be listed among many others.

There is no single established theory as to how these phenomena taken as a whole exert their influences on the future of an economy. Econometric studies intended to analyze these phenomena are also lacking.

The purpose of this dissertation is to provide a theoretical and empirical framework to treat the set of problems with explicit recognition of interrelationships. The model is developed to cover environmental indicators including input of environment to economic activities and output of pollutant; population status indicators including health,

accident rates, crime rate, and hours of work; material benefit indicators including the use of the stock of consumer durables, housing capital, and social capital; density indicators; and speed of social transformation indicators. These variables are integrated into a macro-economic model having primary and non-primary sectors, saving and investment functions, consumption functions, price equations, and export and import functions. The model presented in this study is a combination of an economic development model and a system of social indicators.

The requirement for a new framework may be classified into three questions. First, what does economic development mean in addition to an increase in output? We should be able to answer the question why people tend to feel that they are not benefiting from economic development and growth while most of the conventional economic indicators imply improvement. Recent criticism of economic growth is very likely a criticism of the method of measuring economic growth and not a criticism of growth itself. A suitable measurement of growth should be comprehensive; it should be consistent at the same time and should not involve double counting. Each component should be calculated in a form which permits time series and cross section comparisons of the same economy, as well as comparison among different economies.

This leads us to the second question. How is economic development to be measured? An analytical framework reflecting the real condition of the society must include something more than growth of output as now measured. This is the direction to which the development of social and welfare indicators is moving.[7] It is highly desirable to have a system of indicators rather than a mere listing of various aspects of socio-economic systems. If each component of social indicators is made a part

of a simultaneous system, we can analyze with consistency the relations and impact of a change in one indicator to the other, and we may be able to discuss the policies to bring about a better overall situation.

Third, what are the limits to or constraints on economic growth? Pollution is increasing in all developing economies, but may not be critically serious either in sparsely populated areas or where the level of industrial activity is still low and poverty is the main concern of the people. Military expenditure is always wasteful, but may not be recognized as a leak from otherwise useful products if the economy is suffering from deficient aggregate demand. The constraints can be natural (such as biologically tolerable level of pollution, maximum rate of population increase, or availability of land), technical (such as availability of certain resources, need for larger capital stock to obtain larger output), or social (for example, preference for leisure, demand for larger amount of consumer goods, need to maintain bilateral trade balance, and the need to keep price level stable).[8]

Variables such as life expectancy, birth rate, and death rate have biological limits among population related variables. Among environmental variables, the pollution level has biological or physical limits. Also physically limited are the availability of land, water, and various natural resources. Examples of socially determined levels are:

(1) among population-status indicators: the portion of population considered to be in the working age, school attendance, labor-force participation rate, work hours, industrial-accident rate, traffic-accident rate, the cases of infectious diseases, and military personnel;

(2) among environmental indicators: input of land, input of water, percentage of untreated polluted water and uncollected waste, and the actual level of environmental pollution;

(3) among material benefit indicators: food and non-durable goods consumption, stock of durable consumer goods, housing capital and social capital;

(4) all of the density indicators, including population density, production density, capital stock density, and transportation activity density;

(5) all of speed of transformation indicators, including regional and occupational relocation of labor, and the rate of inflation.

There are more conventional types of limits, for example, the size of foreign market is not limitless; people's desire to save is probably subject to some limitations; and the rate of technological progress made possible by the stock of technological knowledge is also limited.

There is no *a priori* reason to consider these limits to growth insurmountable, absolute limits. Rather, we consider them as constraints in implementing economic policies. We note that they are being recognized as the policy objectives in themselves in an extended framework of socio-economic policy and, hence as one of the subjects of economic studies.

These three questions are mutually related. To delineate the achievement of economic development, we must develop welfare or social indicators. If we have a more complete system of social indicators, we should be able to assess the development of an economy and talk about some constraints placed on continued growth. A theoretical understanding of the limits to growth would add much to the study of economic development and theoretical refinement of welfare and social indicators.

If the target variable is only one and other targets can be ignored, policy formulation is very simple. For example, if growth is the only aim of the policy, growth policy is easy to follow. Even when there are multiple targets, policy formulation would not cause any trouble if the targets can be pursued simultaneously. The problem is that in general we have a situation where pursuit of one target is possible at the expense of the other, and that the trade-off relation is not intuitively apparent. The trade-off situation is one of the factors to be taken into account in the formulation and pursuit of a particular policy measure. Yet, if the interrelationship remains unknown, or is not explicitly stated, we may end up with implementing policies with conflicting effects.[9]

It is our purpose to expand factual understanding about trade-off relations and multi-layer structure of the objectives and tools. Today's economic policy requires objective data and complete recognition of the current situation based on those data. Even when the value judgements tend to be superficially conflicting, multi-layer structure of objectives and tools suggests that it may be possible to reach a common conclusion. The possibility of reaching an agreement as to the relative importance of each component of economic and non-economic factors hinges on the possibility of developing theoretical tools that can be used commonly by all the parties concerned. Within such a framework, we may be able to make conflicting views compatible to each other through the establishment of a mechanism by which each of the different value judgement are compared and analyzed.

As to the problem of the relative importance of the non-economic welfare, we will have to leave it to social value judgement. The provision of the Social Value Committee will be helpful in making the judgement an effective one in a particular society in a particular time.[10]

1.2 Required Framework of the Model

Are these "new" problems really new, and do they render valueless what has been achieved in economics? In this section we relate the new problems to a conventional economic framework.

A survey of existing macro-economic models reveals the common characteristics as are summaried in Figure 1-1.[11] The typical model has production functions, GNP-GNI-GNE equations, a saving function and capital formation equations as standard equipment. It may have price equations if monetary as well as real values are treated. It may be necessary to have foreign trade equations and the government sector in order to analyze aggregate demand. Sometimes, labor equations are included, especially in the case of long-term models. Either a liquidity preference equation may also be added in Keynesian tradition, or it may have supply and demand for money equation in a neo-classical spirit.

As some have suggested, it is possible to make some adjustment to the GNP account in order to reflect welfare implications more properly.[12] Suggested adjustment to GNP includes evaluation of environmental pollution as a negative output, use of a quality improvement index parallel to the consumer price index, evaluation of the amount of leisure time, removal of intermediary, nonbeneficial or wasteful social expenditures from the government account, removal of costs from consumption, and development of imputed values for crucial nonmarket economic activities. Alternative suggestions are social indicators and welfare indicators. Social indicators are in general intended to describe the structural characteristics of a society, whereas welfare indicators are based on the performance of a society and are intended to reflect the welfare output. Social indicators are suitable as the measure of social and economic

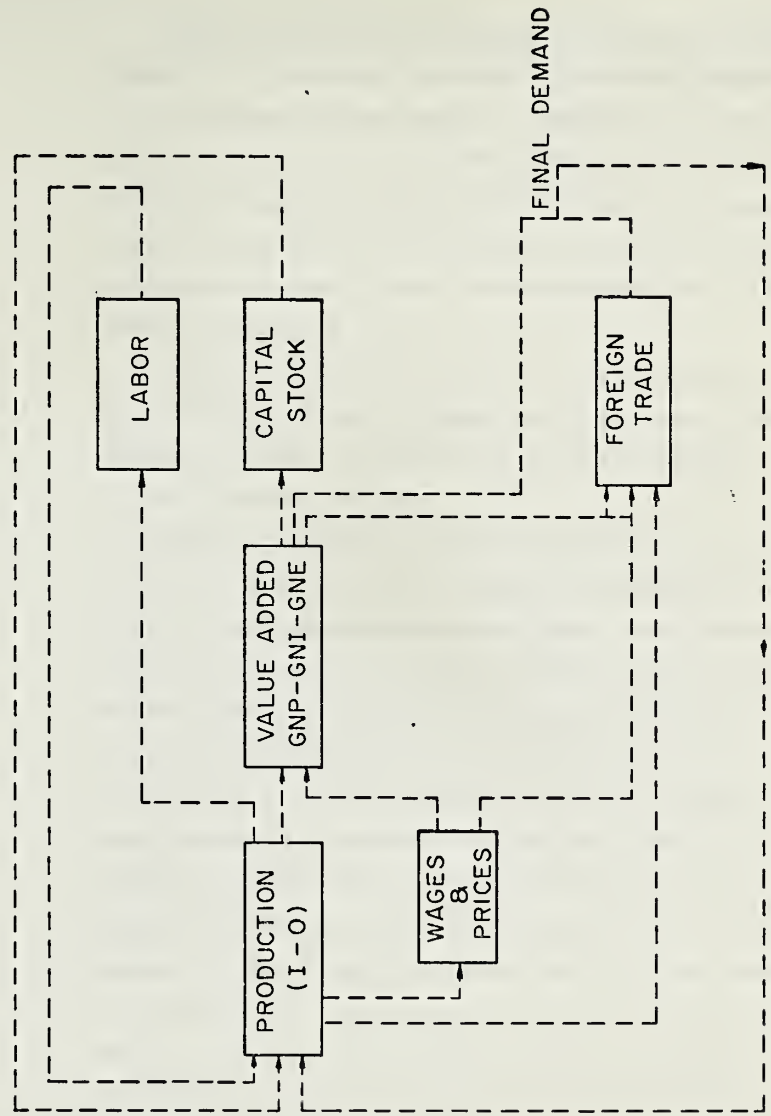

Figure 1-1. Outline of the Conventional Macro-Economic Models

stage of development because they include structural indicators. Welfare indicators are preferable as the measure of the degree of happiness of the people.

Which indicator to use instead of conventional GNP depends upon the purpose of the analysis. Social indicators and welfare indicators, however, do not explicitly recognize the interrelationships within the economic mechanism which exerts powerful influence on non-economic as well as economic aspects of the society, and adjusted GNP does not escape the defects of conventional GNP.

Moreover, the concept of GNP is very useful when we consider effective demand. Effective demand analysis would remain important even if other aspects of the economy were considered simultaneously. The additions or subtractions of GNP components discussed above will diminish the utility of GNP as the tool to analyze effective demand.

In addition, it is doubtful that adjusted GNP alone would suffice to meet the increased complexity of the problems which are imposed upon present day societies. In other words, today's economic problems, at least some of the most urgent ones, are connected with the production-distribution-expenditure sphere only indirectly. On the other hand, emphasis on performance criteria such as social or welfare indicators leads to the neglect to production mechanism, which is influential in limiting the room for policy choice.

Models are conceptual frameworks that set out the variables of concern and specify how they are related. To keep the model manageable, we must reduce the real world complexity to a limited number of dimensions. In so doing we run the risk of discarding important relationships. Which ones are important and which are trivial depends on the problem at hand.

I believe both conventional frameworks of macro models and new indicators fall far short of today's need to measure the economics as well as non-economic welfare factors. By concentrating on either the production mechanism or the performance of the economy, these frameworks and indicators ignore the aspects covered by each other. They both fail to give a whole picture of the interrelated socio-economic system and, consequently, are unable to solve new problems brought about by the operation of today's societies.

I propose a theoretical framework which aims at combining a description of the production mechanism and the performance of the mechanism, with explicit recognition of their interrelationships. Figures 1-2 and 1-3 summarize this point.

In Figure 1-2 we show the enlarged economic system which includes, in addition to more conventional production-centered blocks shown in Figure 1-1, new blocks such as population status, stock of durable consumer goods, stocks of social and housing capital, material benefit indicators derived from the use of various stocks as well as from consumption of currently produced consumer goods, environmental indicators, density indicators, and speed of social transformation indicators. (These new components are marked by shaded areas in Figure 1-2.) Research and development has to be considered explicitly. The dual character of population should be made explicit; i.e., as a factor of production in the capacity of labor force, and as the final beneficiary of economic activity. Therefore, the well-being of the population as reflected in health, school enrollment, industrial and traffic accidents, and crimes is included in the model. The natural environment, i.e., air, water, and land, is indispensable for human life, but is also necessary for production.

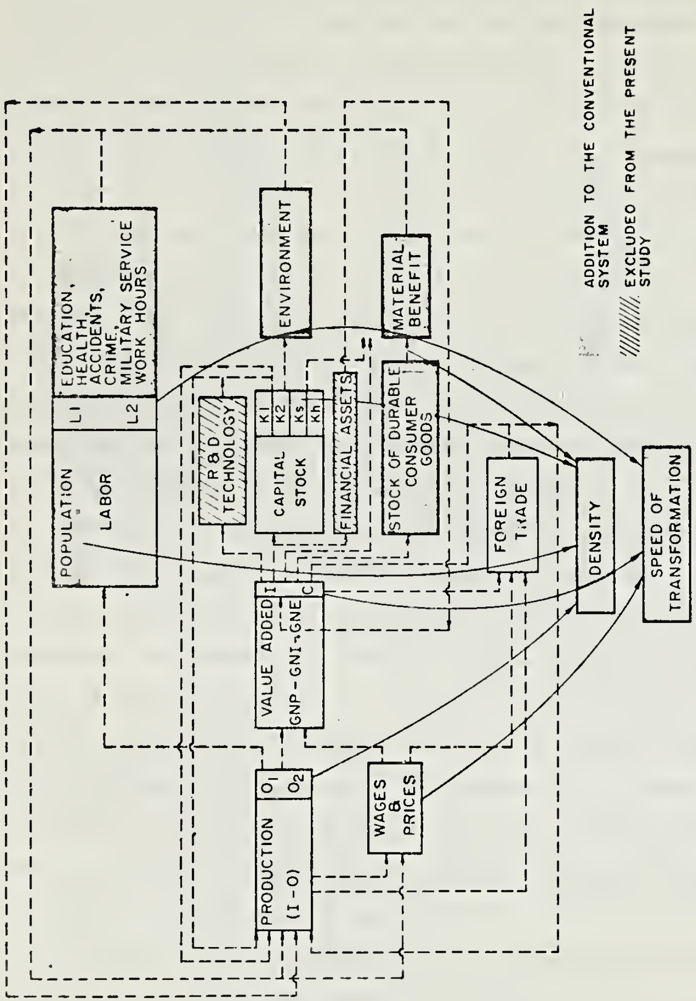

Figure 1-2. Outline of the Enlarged Macro-Economic Model

One can characterize the enlarged economic system model as a closed circuit model: it considers explicitly the effects which economic activities exert on population and the feedback to production activity through changes in the labor force;[13] effects of production and various capital stocks on environment and inputs of environment such as land, water, and air to productive activities;[14] the cumulative effect of production to the consumer's benefit; and density indicators and speed of social transformation indicators which comprise social environment with its feedback on the production sector. Those factors are called "noneconomic" and have not been treated explicitly in the conventional, narrowly defined economic system. Their presence has been noted only when they enter into the production cycle as a factor of production. As has been pointed out, there is increased awareness that these components should be analyzed in their own right. Moreover, the influence of those factors on production activity is becoming more important as a determinant of the level and composition of products and services which the economy turns out annually. Hence, there is a need to build a closed circuit model capable of analyzing the feedback effects.

Another characteristic of our model is that it considers various stocks explicitly. This is a natural outcome of our emphasis on the welfare aspect of the economy. Annual flow of goods and services is only a part of the benefit we derive from participating in economic activities. What is generally termed as standard of living is derived from various stocks, rather than flow. The concept of flow and stock is only for analytical convenience because stock is also flow in the long run. Following this convention, we may identify population and capital as stocks. Status of the population, e.g., whether they are in

the labor force, whether they are employed, whether they are sick or injured, is important in its own right since the final purpose of economic activity is supposed to be the well-being of the people in that society. Stocks of social and housing capital as well as the stock of durable goods are important components of welfare. Also, environmental pollution is more likely to be caused by stocks. The stock of knowledge or technology available to human beings or to one particular society is an important determinant of the level and the rate of growth of production. The stock of knowledge can be varied through research and development activity. Density indicators are defined in terms of stocks, as well as in terms of flow. The amount of the stock of resources actually or potentially useful to economic activity are argued to be limited; annual use of these limited resources may pose grave problems.

This work develops the simplest possible account of the enlarged economic system explained in Figure 1-2, a needed first step[15] and actually the most that can be done at present, given the level of theoretical development and the amount of empirical knowledge in this field. Further development of the theoretical framework and additional empirical knowledge of the enlarged economic system explained in Figure 1-2 is necessary for a more complete investigation of the "welfare" implications of economic activities. In this sense, a formalization of the enlarged economic model would be a significant contribution toward contemporary socio-economic problems.

The analysis of the enlarged economic system would provide direct insight into some of the new problems we have listed earlier. In addition, however, it would be necessary in some cases to introduce the desired level of the indicators to obtain a complete picture of what is

happening in the society objectively and what the public feels about it subjectively. The level of "satisfaction" usually means the gap between some desired level of these indicators and the actual (i.e., $X^* - X$, where X is the actual level of an indicator, and X^* denoting the desired level) in addition to the absolute level. This point is shown in Figure 1-3. Economists have tended to evaluate the situation objectively by the level attained relative to some past level; people in general seems to evaluate the same situation subjectively based on the gap between the present level and the level they would want to realize based on their increased income level. Apparently the desired level is a function of income and, consequently, changes constantly as income levels change. There is a possibility that an increased level of income would lessen the sense of satisfaction as the gap between desired level and actual level widens, unless policy makers have some means of knowing the desires of the people at some future time under the income level to be attained by that time.

Both actual and the desired levels of these newly added factors (accounts) must be estimated in order to measure the level of satisfaction. Only then can we discuss the gap between the two which may be called the "dissonance" within the economic system. The desirable levels are sometimes well defined, such as biological or physical limitations, but in many cases these are the levels which are considered tolerable by members of the society within a particular income bracket or life style. In such cases, opinion surveys might have to be employed to quantify the actual value of the limits. Or this value could be approximated by the international average of the levels observed in countries with comparable levels of per capita income or by the best level attained in the world.

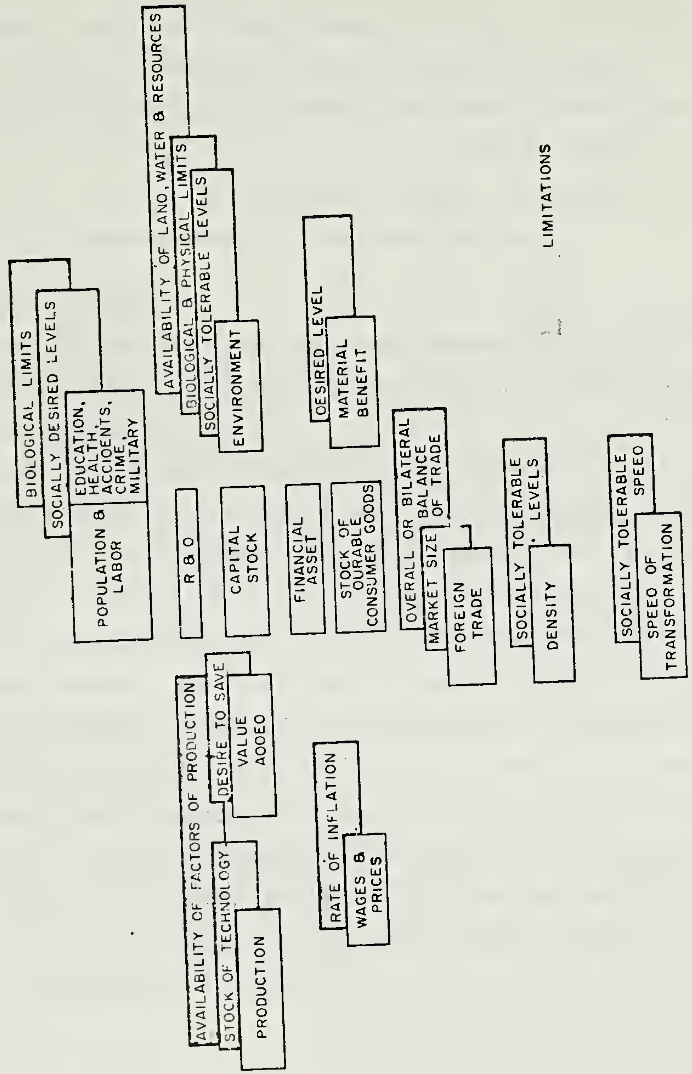

Figure 1-3. Limitations of the Enlarged Macro-Economic Model

This model will serve as the basis for an analysis of this aspect, too. We can compare the predicted values calculated from our model against these limits. The model is capable of showing the repercussions of a change in one variable throughout and in terms of other components in the system.

Further it may be possible to say that the degree of dissonance in a given society indicates the kind of economic system most suitable for that society. For example, a country with high dissonance may be obliged to choose some kind of central coordination to ensure the solution of the problem within designated time horizon, whereas a country with low dissonance can afford the eventual solution by a market mechanism, even when it is believed that the former is quicker.[16] We are referring to not only the distribution of resources among competing ends, but also the dissonance which might occur between the availability of and the demand for space, such as the urgent need to build up industrial basis or military power to defend the survival of the society. Or it could involve a shortage of the labor force or the threatening exhaustion of some natural resource. Finally, dissonance could occur between the desired rate of economic growth and the adaptability of people to new jobs, new attitudes or new place of work which such changes require of them. In addition, some intervention might be required to prevent or solve the environmental pollution.

Thus, the choice of economic system could be quantified, subject to certain assumptions about how to measure dissonance in a society. The final objective of this study is to analyze the interaction of the economic system, the stage of economic development, and the reflection of various international relations to the economis system in a society.

If this kind of model were empirically developed for different economies, it might be possible to distinguish among the differences resulting from various economic systems, those caused by disparities in stages of economic development and those resulting from different burdens arising from international relations as reflected in the level of military expenditures as well as in research and development expenditures. This model of the Japanese economy is a step toward this end.[17]

1.3 Japan, 1950-1970

Empirical data is based on the Japanese experience during 1950-1970, a short period but the only period for which data on the expended aspects of the economy is available.[18]

The years immediately following the end of the World War II are considered "not normal" due to the destruction and disorganiation caused by the war and to implementation of various reforms; therefore, they are excluded.[19] However, 1949 is properly considered an economic epoch. In 1949, a stabilization policy was carried out which restricted government spending and credit. At the same time, a single exchange rate (as opposed to multiple exchange rates that had existed) of 360 yen to the dollar was established, a rate which remained until 1971, when it was revalued to 308 yen to the dollar. This does not mean, however, that the impact of the war had completely faded away by 1950. Pre-war peaks for the GNP were not reached until around 1954, output per head not until 1957, and export volume not until 1959. Occupation continued until independence was restored in 1952.

1.4 The Tools of Analysis

We use an econometric model in this study. An aggregate econometric model allows us, indeed requires us, to trace not only the direct effect but also the repercussion of the initial change in one of the parameters to the rest of the system. It is less arbitrary than verbal discussion in which we tend to put relative weights on certain things without always stating objectifiable grounds.

1.5 Plan of the Dissertation

Following Chapter 1, in which problems are raised and the general outline as well as theoretical framework of the model is presented, Chapter 2 discusses the variables which are required for the purpose of the study. The variables are listed from three viewpoints in terms of the model, i.e., as a system of social and welfare indicators, as an economic development model, and as a model to analyze the possible constraints on Japanese growth. Chapter 3 presents the structure and causal flow of the model. Some interesting empirical findings regarding individual equations are pointed out and comparisons with the past works are made. Finally, Chapter 4 shows the result of simulation test of the model using the derived reduced-form coefficients and illustrates the overall accuracy of the model. The conclusions and policy implications are derived from the observations of the projection of the economy for the future.

FOOTNOTES FOR CHAPTER 1

[1]For production and GNP statistics, see Appendix C of this study. For international comparisons of per capita production of selected items, see the table below.

Per capita production level in 1970 (U.S. = 100)

	Japan	U.K.	W. Germany
Synthetic fiber	249.0	99.6*	63.6*
Newspaper roll	124.8	93.4	47.2
Plastics	127.2	62.4	189.9
Cement	163.1	90.4	190.6
Crude steel	155.4	87.8	132.2
Aluminum	48.8	20.7	46.5
Synthetic rubber	62.1	45.0*	50.3
Passenger cars	96.2	92.3	188.1
Trucks	249.0	99.6	63.6
Ships	3869.0#	6154.6#	1072.7#
TV receiver	180.6#	71.6#	87.4#
Electricity	43.5	55.4	51.7

- 1968, * - 1969.
Source: Economic Planning Agency, Keizai Hakusho 1971, pp. 87-88.

[2]Subjective evaluation of economic growth according to "Opinion Survey Concerning Social Evaluation" by the Office of the Prime Minister in March 1971 shows following result:

unit: percent

beneficial	harmful	equally beneficial and harmful	inconclusive	no opinion
26.5	13.7	29.1	18.4	12.2

Source: Economic Planning Agency, Kokumin Seikatsu Hakusho 1971, p. 394. According to another survey titled "Opinion Survey Concerning People's Living" by the Office of the Prime Minister in January 1971, the items people judge as improved or as worsened are shown below. The opinions expressed form an evaluation of the present living environment as compared to that of several years ago.

unit: percent

(1) improved

traffic networks	educational, cultural, & medical facilities	sewerage & waste disposal	water-works, gas, & elec-tricity	shopping facilities	other	nothing
38.0	10.5	19.3	10.5	12.7	0.9	32.8

(2) worsened

noise, smog, & smell	water pollution	traffic con-gestion	excessive density	excessive sparsity	other	nothing
20.9	14.8	30.7	9.0	2.9	1.6	42.6

Source: Economic Planning Agency, ibid., p. 395.

[3]Economic Planning Agency, ibid., p. 127.

[4]Population density is as follows:

	total area: 1000km^2	population density: person/km^2
Japan	370	270
U.S.	9363	21
W. Germany	248	233
U.K.	244	226

Density of economic activity (GNP/km^2) in Japan is 11 times larger than the U.S. level, 2 times the German level, and 4 times the U.K. level.
Source: Ministry of Construction, Kensetsu Hakusho 1970, pp. 44-45.

[5]Ministry of International Trade and Industry, Tsusho Hakusho 1971, pp. 142-143 gives the following statistics concerning growth rates:

		Japan	U.S.	W. Germany	U.K.
GNP (real)	50's	7.9	2.6	7.7	2.7
	60's	10.6	4.9	4.4	2.9
Industrial production	50's	13.4	3.0	8.4	3.0
	60's	13.1	5.8	5.0	3.2

According to the same source (p. 250), industrial growth of the Soviet Union was 12.3% for 1951-55, 9.6% for 1956-60, 8.1% for 1961-65, and 8.5% for 1966-69.

[6] For what has been considered as the objectives of economic policy, see, for example, Kirschen, et al., fp. 148.

[7] Adelman and Morris (1967) (1968) (1970); Bauer; Gross and Springer; Sheldon and Moore (1966) (1968); Springer; The U.S. Department of Health, Education, and Welfare; Zennihon Rodo Sodomei. For a bibliography in this field, see Agocs. A summary of selected works is presented in Appendix B of this study.

[8] Shinohara (1970), especially p. 153, for the balance of payments ceiling and the full employment ceiling in Japan.

[9] Tinbergen (1954), p. 61, defines four classes of instruments: supporting, conflicting, neutral, and mixed.

[10] As an example of such provisions, see Alvin Hansen's proposal of a Council of Social Values. Hansen, p. 91.

[11] See Appendix A of this study for a summary of existing econometric models on the Japanese economy. A tabular survey of major macro-economic models for U.S., Canada, Australia, U.K., Netherland, Germany, Italy, Japan, and India up to 1965 is published in Nerlove. For more recent models, see De Leeuw; Ball; Duesenberry, et al. (1965) (1969); Evans (1966) (1968) (1969); Fisher; Liebenberg, et al.; Niwa (1966) (1971); Morishima and Saito; Rasche and Shapiro; and Thurow.

[12] See, for example, Sheldon and Moore (1968), p. 90.

[13] For an attempt to approach today's problems as a total closed system, see Meadows. Holland and Gillespie, p. 219, provides a sketch of such flow, although the scope is rather limited. For sketchy flowcharts of population-production relations, see Hama (April 1970), p. 47; Oniki, p. 59.

[14] For an ecological viewpoint, see, for example, Culbertson.

[15] This kind of model has not been attempted, although the need for it has been expressed, for example, by Sheldon and Moore (1968), p. 4.

[16] Tinbergen (1964), p. 65. "...we may expect planning to have a larger positive impact on the economy in situations where
1) there is a more pronounced need for forecasts;
2) there is a more pronounced need to stick to some aims; or
3) there is a more pronounced need for coordination."
The Economic Deliberation Committee (of Japan) describes the roles of plans in a basically free market economy as

1) promotional and educational role through forecasting;
2) statement of long-term policy goals based on government plan; and
3) adjustment of conflicting interests.
See Nihonno Keizai Keikaku, p. 13.

Our suggestion is pertinent to the measurement of these "needs". In the long-run, a choice of economic system could be subject to a policy decision, quite apart from ideological grounds. Or, we might say that the ideology of a particular society in a particular time reflects the needs of the society, perhaps with some time lags. Industrial organization itself affects productive power of an industry or of a country as a factor of production distinct from labor, land, and capital. The plan makes possible a series of economic policies based on a consistent forecast of the national economy. It also lowers investment risks by showing the results of a generalized market survey.

More specifically, as Abegglen points out, the Japanese Government seeks to do four things:
1) to provide a flow of capital adequate for maximum growth but not so large as to permit overactivity which leads to inflation and shortages of goods;
2) to stabilize the rate at which labor is displaced from older industries at a level that can be fully absorbed by the new high growth, high capital industries;
3) to concentrate investment in the industries in which Japan can best compete worldwide; and
4) to protect domestic industry until it has the technological maturity and size to be self-sufficient

In addition to the need or the demand for planning, we should also consider the supply side which consists of:
1) the technical competence and integrity of the administration;
2) the level of literacy and the civic spirit; and
3) the availability of data.
See Tinbergen (1964), p. 71.

These considerations would give us better and clearer understanding of the theory of convergence. For convergence theory, see, among others, Grossman, pp. 111-113; Wiles (1963) (1967); Tinbergen (1961); USSR State Economic Council.

[17] For Japanese economic plans, see Economic Planning Agency (1965-1) (1965-2) (1968) (1970-1) (1970-2). As a rare attempt to reveal the decision making process of plan-making, see Kato Kenkyukai, where a lack of consumer group and labor union as participants in decision making process is pointed out. This probably reflects the lack of recognition of extra-economic factors in Japanese plans.

[18] For a general description of the Japanese economy in English, see Allen (1963) (1965); Lockwood; Maddison (1969) (1970); Shinohara (1962); Watanabe (April 1965); The Economist (1962) (1967); and in Japanese, see Shinohara (1965) (1967); various annual White Papers, including Keizai Hakusho, Kokumin Seikatsu Hakusho, Kogai Hakusho (title changed to

Kankyo Hakusho in 1972), Tsusho Hakusho, Rodo Hakusho, and Kensetsu Hakusho. For statistical material, note Bank of Japan, Hundred-Year Statistics of the Japanese Economy, Japan Statistical Yearbook, and Economic Planning Agency, Annual Report on National Income Statistics. For international comparisons, see United Nations, Statistical Yearbook, Yearbook of International Trade Statistics, Yearbook of National Accounts Statistics; IMF, International Financial Statistics; ILO, Yearbook of Labour Statistics; and Bank of Japan, Nihon Keizaio Chushintosuru Kokusai Hikaku Tokei.

[19] For war damage, see Hundred-Year Statistics of the Japanese Economy, p. 27. Japan also lost her colonies in Manchuria, Korea, Taiwan, Karafuto, and Kuriles. Okinawa ceased to be a part of Japan. Reforms carried out includes agricultural land reform and dissolution of Zaibatsus. For the land reform, see Dore, Kawano.

CHAPTER 2

VARIABLES TO BE INCLUDED IN THE MODEL

The model presented in this study is designed to encompass three different, yet mutually related, aspects of an enlarged socio-economic system as has been explained in Section 1.1. To facilitate exposition, the variables included in the model will be discussed from these three different views. These are (1) as a social and welfare indicator model, (2) an an economic development model, and (3) as a model to consider possible constraints to continued growth.

2.1 Social and Welfare Indicators

A system of social indicators or welfare indicators at the macro-level is developed in this section. This has been done in order to build a system compatible with the conventional economic model. No distinction between urban and rural is made so as to keep the model manageable. For the sake of brevity, only a list is given for the social or welfare indicator related variables which are treated in the model.[1]

Listed here are, in general, those variables which appear in the model either as endogenous or exogenous. Many others may be derived using those which are included in the model.

The model is not designed to obtain social or welfare indicators on a scalar magnitude. There is a problem of additivity of various indicators in different units of measurement. This may not be insurmountable, as Sheldon and Moore suggest, if the use of fixed weights for various components is justified.[2] This procedure, however, is untenable when the weight to be attached to each component is likely to change over time as a result of changing public recognition of each component or the

Table 2-1

Social Indicator Related Variables

	Variables in the model
Population status indicators	
Birth rate	b
Death rate (other than infants)	da
Death rate for infants	db
Life expectancy	LE
School attendance among working age population	E
Labor force participation	L/N*
Work hours in non-primary sector	H
Unemployment rate	u
Labor disputes	l
Military personnel	m
Industrial accidents	ai
Traffic accidents	at
Infectious diseases	ad
Inmates of institutions	v
Diseases caused by environmental pollution	az
Environmental indicators	
Input of land	A2hs
Rate of land utilization	a
Input of water	Zwater
Rate of water utilization	w
Output of polluted water	Zwater
Output of air pollutant	Zair
Output of household and industrial waste	Zwaste
Percentage of untreated polluted water	zwater
Percentage of uncollected waste	zwaste
Water pollution level	ZBOD
Air pollution level	ZSO2, ZCO
General environmental condition	Z

Table 2-1 (continued)

	Variables in the model
Material benefit indicators	
Consumption of food	Cf
Consumption of durable customer goods	Cd
Consumption of non-durable consumer goods	Cc
Imputed benefit from stock of durable consumer goods	$i \cdot \Sigma Cd$
Imputed benefit from use of social capital stock for final use	$i \cdot c \cdot Ks$
Imputed benefit from use of housing capital stock	$i \cdot Kh$
Density indicators	
Population density	ND
Production density	YD
Capital stock density	KD
Transportation activity density	TD
Energy and transportation indicators	
Energy consumption	EC
Transportation activity	TA
Speed of social transformation indicators	
Regional relocation of population	RR
Occupational relocation	to be derived as $(L2/L)_t/(L2/L)_{t-1}$
Growth rates	to be derived
Price stability	
Price indices	P, Pc, P1, P2, Ps, Pa, Px

relative importance of the components is the problem in question. If this is the case, the use of fixed weights pertinent to one particular point in time has only limited validity. In general, specific values can be assigned to the weights only when the purpose of the study is made explicit.

The model presented here is a general model covering variables related to social indicators, welfare indicators, conventional and adjusted GNP, production indices, and various consumption levels. Using the foreign exchange rate, the values in dollar terms as well as in local currency may be obtained for many variables. Specific indicators may be defined using the variables included in the model, given the weights from outside the model according to the purpose of the experiments. Such weights are obtainable based on opinion polls and other methods of collecting judgement of the public; the weights also could be those of the policy authority.

A summary of selected works on social and welfare indicators and their relation to this study is presented in Appendix A.

2.2 Key Variables for Economic Development

There are some variables in the model which are of strategic importance in economic development.[3] They belong to the GNP generating mechanism and have been treated in macro-economic models. They are listed in Table 2-2.

These refer to the strategic variables for economic development which describe the structural mechanism of the economy, whereas the social indicators presented in the previous section reflect what has been achieved by increased production. It should be noted that the growth and

Table 2-2

Key Variables for Economic Development

	Variables in the model
Prices and wages	
Primary products price (or its relation to the nonprimary wage level)	P1
Non-primary products price	P2
Terms of trade between primary and non-primary sectors	P1/P2
Wage rate in non-primary sector (or its dependence on productivity)	W2/L2
Service price (or its relation to the non-primary wage level)	Ps
General wholesale price	P
Consumer price	Pc
Production	
Primary sector output	Q1
Non-primary sector output	Q2
GNP-GNE	
Value added in primary sector (or the influence of primary products price)	Y1
Value added in non-primary sector	Y2
Gross national product and its growth rate	Y
Saving rate	S/Y
Primary sector capital formation	I1
Non-primary sector capital formation	I2
Social capital formation	Is
Housing capital formation	Ih
Rate of capacity utilization	r
Foreign trade	
Balance of trade	B
Exchange rate	x

Table 2-2 (continued)

	Variables in the model
<u>Labor</u>	
Population (or rate of population increase)	N
Share of working age population	N*/N
Labor force participation	L/N*
Labor force allocation between primary and non-primary factors	L2/L
<u>Technical progress</u>	
Rate of technical progress	T

development aspect has been included in the conventional treatment of the economic system, and growth and development variables constitute the system described in Figure 1-1. On the other hand, macro-social indicators are the variables which appear in the expanded system of the economy described in Figure 1-2. They belong to population status, environmental, material benefit, density, or speed of transformation indicators.

By confining social indicators to the macro level, the approach of this study to social indicators comes close to studying the result of economic development or performance of the economy. It is often pointed out that the traditional approach to economic development is deficient in that it focuses attention on the production side of economic activity.[4] The present model is capable of describing the changes which accompany economic development from more diversified viewpoints. This model will be able to analyze how the health, educational level, or labor force participation of population change as an economy grows; these aspects are reflected in population status indicators. Material benefit indicators will tell us how consumer-oriented indicators react to the process of industrialization.

Further, the model is capable of analyzing the effect of alternative development policies as reflected in the macro-social indicators. One can ask, for example, how the maximum welfare policy, which we define appropriately according to the purpose of the experiment, would yield a welfare level in the future.

One advantage of this model over a more conventional approach is that this model explicitly considers various stocks whereas the latter considers variables on annual flow of goods and services and only take

stocks into account if they are pertinent to the production process. Annual flow of goods and services should not be identified with actual economic welfare. It should be recognized that the stocks, and the utilities derived from them, would keep changing through annual addition even when the amount of the annual flow remains constant.

The relation of growth and development mechanism and social indicators is not simply that the latter are derived from the former. In reality, there exists a feedback mechanism from the latter to the former. Existing macro-economic models and social indicators tend to ignore this point (as can be witnessed from the summaries of these works provided in Appendix B of this study). As the development process continues, labor force or natural resources cease to be abundant. The quality of the labor force, and not simply its quantity, becomes important in matching the sophistication of the production process. Income will be weighted against leisure, and workers will become more reluctant to sacrifice their leisure for the sake of increased income. The importance of durable consumer goods in consumption life becomes greater, and requires an increased supply of social capital, as can be seen in the relation of production of automobiles and increased demand for highways. Housing capital is also supplementary to durable consumer goods. Housing capital and social capital cannot be regarded as mere leakage from the flow of investment; the economy cannot "economize" on these items. Otherwise the gap between what people desire in relation to their productive power and income and what is provided by the system will widen, resulting in a higher degree of dissonance and tending to the distrust of the system. Density and speed of transformation will be recognized as undesirable aspects of economic growth when not accompanied by

appropriate policy. For example, increased density can be neutralized by increased supply of social capital. Output of pollutants will increase as production and consumption levels increase; unless pollution prevention measures are taken this will result in increasing level of environmental pollution.

Thus it is realized that social indicators are not merely derived variables from production mechanism; social benefits do have their effect on the production mechanism by posing new limits within which the economy has to operate. In this sense, the production mechanism and the system of social benefits form an integral whole, connected by a complicated feedback system. Limitations to growth exist not only in the production mechanism itself but also in the changing conditions of social benefits. This leads us to a discussion of possible constraints on continued growth.

2.3 Possible Constraints to Growth

To be consistent with existing literature on growth and development and for the sake of theoretical clarity, various factors, considered as possible constraints to growth, are classified below:[5]

1. Capital and capital utilization rate
2. Labor and work hours
3. Technical progress
4. Availability of resources, land, and water
5. Environmental pollution
6. International trade
7. Speed of transformation and price stability
8. Density

In the following sections, individual factors under each heading will be discussed briefly. They are summarized in Table 2-3. Their incorporation into the model structure will be discussed in the next chapter. Most of the variables in the list are treated as endogenous in the model. Some of them should be treated as exogenous policy variables when we examine the effect of alternative policies. Treating all of the possible candidates for policy simulation as exogenous would be infeasible.

2.3.1 Capital Formation and Capital Utilization Rate

Saving ratio: It is expected that in the long run aggregate demand would be maintained by proper policy measures at a level which is sufficient to absorb the productive capacity of the economy,[6] although this does not rule out the possibility of business cycles. Therefore this model focuses on the supply side rather than on the effective demand side. The saving ratio is the key parameter in judging the future of an economy because it determines the future supply capacity of the economy.

One of the factors contributing to sustained high growth rate in Japan is the saving ratio which has been kept very high compared to any other country in the world, averaging 37 percent in the 15 year period from 1956 to 1970. In recent years the ratio is even high reaching 42 percent.[7] An important question is whether this ratio can be maintained in the future.[8]

Some economists, however, foresee a decrease in the saving ratio. Kurihara, for example, gives the following reasons:[9]

(1) redistribution of income from profit makers to wage earners

(2) the enlargement of consumer credit

(3) greater reliance on progressive income taxes

(4) the consumers' quest for gadgetry and modernity

Table 2-3

List of Possible Constraints Considered in the Model

1. Capital and capital utilization rate	
Saving rate	S/Y*
Social capital formation	Is
Housing capital formation	Ih
Share of social capital stock for final use	c
Share of pollution prevention investment	Iz/I2
Military expenditure	YM
Research and development expenditure	YRD
Rate of capacity utilization in non-primary sector	T
2. Labor and work hours	
Share of working age population	N*/N
Labor force participation	L/N*
Military personnel	m
Work hours in non-primary sector	H
3. Technical progresss	
Shift term in production function (rate of "technical progress")	T
Research and development expenditure	YRD
4. Availability of land, water, and resources	
Rate of land utilization	a
Rate of water utilization	w
Output of air pollutant (or consumption of petroleum and coal in world production)	Zair
Energy consumption	EC
5. Environmental pollution	
Output of air polluant	Zair
Output of waste	Zwaste
Output of polluted water	Zwater
Waste collection rate	Zwaste
Water pollutant removal rate (sewerage diffusion rate)	Zwater
Water pollution level; biological oxygen demand	ZBOD
Air pollution level; SO_2	ZSO2
" " " ; CO^2	ZCO

Table 2-3 (continued)

Share of motor vehicle in transportation activity	wmv
Share of petroleum and coal energy in total energy consumption	wpc
6. International trade	
Balance of trade	B
Exchange rate	x
7. Density	
Population density	ND
Production density	YD
Capital stock density	KD
Transportation activity density	TD
8. Speed of social transformation	
Regional relocation of population	RR
Occupational relocation	
9. Price stability	
Consumer price increase	P

(5) mass advertising

(6) conspicuous consumption; and

(7) "keeping up with domestic and foreign Jones."

Others add such elements as lack of social security, which forced people to save in order to prepare for an emergency and for old age. Perhaps this paucity will be mended in the near future, with the result that saving ratios will go down.

A counter argument can be made based on the same reasons in the above list, namely (5), (6) and (7), that these factors could work to foster savings at the same time because we should expect that demonstration effect works for savings as well as for consumption. In Japan, the average actual and desired levels of financial assets per household are periodically surveyed and publicized through the mass media. Another counter argument is based on stock effects. If the household aims at maintaining a constant ratio between its current income and financial assets, higher growth would necessitate a higher saving ratio.[10] Another possibility of higher growth feeding a higher saving ratio is the stickiness of consumption levels. If the consumption level tends to adjust slowly to a higher level of income, it is reasonable to expect that the saving rate would be maintained in a growing economy.[11] Finally, it is conceivable that in an economy where the standard of living is constantly rising, future retirement funds are also expected to be larger, thus fostering current savings rates.

This model seeks to establish the relation between economic growth rate and the saving rate and includes the saving ratio as an endogenous variable.[12] Some other forms of savings function may be tested.[13]

Social capital formation and the share of social capital stock for final use: The definition of social capital stock in this study includes buildings and structure which are under either national or public ownership, and excludes those belonging to operative government organizations and government corporations.[14] In national income accounts, this corresponds to "gross fixed capital formation, general government" and does not include government enterprises and public corporations. The definition has to be operational in order for an empirical analysis to be conducted. Some private investment is also "social" in its function, but is not included due to the difficulty in obtaining data when purely functional definitions are required.

Housing capital can be considered overhead capital and can be grouped with social capital. However, due to its direct welfare effect and from its weight in total capital stock, it is treated as a separate category in this study.

In the past, social capital which is closely related to production activity has increased to meet the rapid industrial expansion, to the neglect of what are considered to be non-productive by the policy authority.[15] There are reasons to believe that the share of social capital which will benefit the consumer and not the producer would increase in the future.[16] In this study this is called the share of social capital stock for "final use"; i.e., the satisfaction (or the imputed users' benefit) from the use of social capital is one component of material benefit which consists of current consumption and use of various stocks. However it may be that the possibility of substitution among the stocks is very limited. Each component should be considered supplementary to the other. In other words, increased stock of consumer

durables cannot make up for the lack of social capital or housing capital; rather, increased stock of consumer durables requires a proportional or more than a proportional increase in other items. Without this increase, greater supply of consumer durables would add to dissatisfaction instead of increasing consumer satisfaction.

Another source of the need for increased social capital is environmental pollution control.[17] A portion of pollution can be prevented at the production site through an increase in pollution prevention capital. However, removal of pollutants such as waste water and solid waste would require more sewerage, sanitary treatment facilities and incinerators.[18]

Thus, it is required to treat explicitly the social capital and to distinguish a portion of the social capital for "final use".

Housing capital formation: The shortage of housing capital in Japan is aggravated by the damage incurred by World War II and by extremely rapid urbanization. Throughout the period under consideration, housing capital formation has been underprivileged financially.[19] Coupled with increased demand for better quality housing as a result of the increased income level,[20] the gap between the desired level of housing stock and the actual level has never been narrowed despite the fact that Japan's construction of housing units is reaching 1,480,000 units per year in 1970.[21]

This model as it stands includes housing capital formation as an endogenous variable. According to the purpose of experiment, this variable may be removed from the endogenous list and treated as exogenous.

Rate of capacity utilization in non-primary sector: In the past, the Japanese producers had a tendency to operate at capacity. The high break even-point, set by fixed labor costs due to permanent

employment system and debt costs due to heavy reliance on borrowing, means that new facilities are operated at capacity. The tendency is reinforced by the expectation of growth, which makes it of overriding importance for a firm to maintain its share of the market, regardless of current profits.

For the future, two factors affecting the rate of capacity utilization may be distinguished. One is of the short run nature caused by business cycles. Although Keynesian economics explains how to cope with such a situation, complete elimination of cycles certainly was not achieved in the past, and will be difficult in the future.

Another major source affecting the rate of capacity utilization is oligopoly. It is conceivable that as a result of technological requirements, the efficient production unit becomes quite large with the result that only a few units are needed in an economy, firms might merge purely for profits, thus eliminating competition. At any rate, the possibility of decreased utilization of production capacity as the economy becomes oligopolistic cannot be denied. Lower utilization of capacity will certainly result in lower output per unit of capital and widening gap between potential and actual GNP.[22]

This model takes into account the rate of capacity utilization in a non-primary sector as an exogenous variable in recognition of its fluctuations in the past and to allow for experimentation in the future.

The share of military expenditure in GNP: Military expenditures, while capable of increasing effective demand, add nothing to productive capacity. The most important implication of demilitarization in post-World War II Japan is that a far greater proportion of annual flow of goods and services is thereby made available for other uses including

consumption and capital formation than in the past or in other major countries.[23] A short-run boost of effective demand by military expenditure can be substituted by increase in private investment and construction of social and housing capital under appropriate policy in any society. Especially where a shortage of supply capacity rather than effective demand is the main concern, as is true in less developed countries including Japan and the U.S.S.R., military expenditure is nothing but a waste from a purely economic viewpoint.[24]

Since Japan has to import raw materials from virtually all countries of the world, she would either have to be a super military power to be able to protect uninterrupted supply of these raw materials or find other ways of securing the continuous flow, e.g. through peace keeping effort by economic and technical aid to all parties concerned. Although the Japanese have favored the latter course since World War II, future policy may be different.

The concensus reached so far seems to be to keep the military expenditure less than one percent of GNP. Actually, there are cases when the military budget was reduced to keep it within the implicit limit. Currently, its share in GNP is 0.88%. However its growth rate has been rapid, reflecting high growth rate of GNP: it jumped 19.7% in 1972 from the 1971 level (gross of price change).

In this model this item is treated explicitly. Unlike the effective demand model, military expenditure is considered as a leak from GNP because the shortage of effective demand has never been nor will be a problem in Japan, judging from a rather meagre social and housing capital stock.

<u>The share of pollution prevention investment</u>: The share of pollution prevention investment in total investment on machinery and equipment has been steadily increasing. It has jumped from 5.3% in 1970 to 9.1% in 1971 and 11.5% (planned) in 1973 in manufacturing, mining, and utility industries.[25] The rapid increase in the last two years or so is attributed to the expiration of the deferment period of pollution regulations by Air Pollution Prevention Law and Water Pollution Prevention Law in July 1972.[26] Another contributing factor is the pollution prevention agreements between local governments and the firms which, in many cases, require more severe restrictions than the national regulations.[27]

Pollution prevention investment will increase the welfare level of Japan by reducing negative production activity attributed to output of pollutant and deterioration of environment. On the other hand, it constitutes a leak from the reproduction cycle because it does not increase productive capacity. Hence, there is a need to distinguish the portion of investment going into the prevention of pollution.

2.3.2 Labor Force and Work Hours

The tightening of the Japanese labor market is apparent in many labor statistics. In 1958, for example, there were 1.2 openings for each junior high school graduate and 1.1 for senior high school graduates; in 1970, there were 5.8 and 7.1, respectively.[28]

The future of the labor force depends on

(1) total population,

(2) the ratio of working age population (15 years of age and older) to the total, and

(3) the labor force participation rate.

The labor force is obtained as the product of these three factors. The possibility of introducing foreign workers is excluded in this work. In addition, it is necessary to consider the future trends of work hours in evaluating the total supply of labor. In the following pages, we shall take up these items one by one. The spread of cybernetics might be considered as a possible source of labor force, but this is treated as a labor saving technology and requires increased capital input.

<u>Dependency rates</u>: The effect of changing dependency rates will be felt in several ways. First, it will have direct bearing on the size of labor force relative to the total population. Second, welfare measures required would be affected; for example, if the old aged bracket increases its share, provision for medicare, pension, and proper accomodations will become necessary. Third, the saving ratio may be affected by changing the dependency ratio.[29]

Of these effects, this model considers the first one. A slower growth in the working age population is predicted for Japan. With a rapid decline in birth rate, the share of 0-14 years of age bracket will drop from the current 24% to close to 21% in 1985. The annual increase of working age population (15-64 bracket) will drop from 1,390,000 in 1955-65 period to 620,000 during 1975-1985 period. On the other hand, the share of old aged people (65 and over) is predicted to increase from 7% in 1970 to 10% in 1985, reflecting longer life expectancy. This would indicate extensive repercussions in the labor force, including a shortage of young laborers and the need to employ more female laborers, and old aged workers.[30]

An explicit treatment of this variable in the model enables us to see how it has favored Japan's growth in the sample period. International

comparison of the rates would also reveal the advantages the Japanese economy has in this respect.[31]

Labor force participation rate: Important factors determining the labor force participation rate are: (1) urbanization, (2) education, and (3) stages of economic development.[32]

As urbanization proceeds, the female participation rate is expected to decline. Japan's female labor force participation rate is relatively high (50%) compared to the international rate. This is attributable to the female labor force in rural areas (65%), while the rate in urban areas in not particularly high (44%).

The next factor is educational level which has been increasing in the past years. A decline of the participation rate is particularly marked for ages 15-19 and is a result of increased attendance at senior high schools, colleges and universities.[33] In 1970, attendance at senior high schools was 82.1% (average of male and female) and colleges and universities, 24.3% of the corresponding age brackets, respectively.[34] School attendance is expected to continue to rise with the result that the labor force participation rate among the younger generation will decline.[35]

It is difficult to assess the effect of economic development of labor force participation rate. With the development of an old age pension and an insurance system, retirement age might be lowered. On the other hand, improvements of housing and nursery schools would make female labor participation higher due to wage increases reflecting a shortage of labor will absorb a larger percentage of the working age population into labor force. On the whole, the labor supply would be fairly elastic; this is particularly true in the case of the female

labor force.[36] On the other hand, money income might cease to be a prime concern of the people in the future. Thus, it will be difficult to induce people to work merely for money.

The first of these three factors on page 44 cannot be considered in this model because the urban-rural distinction and the male-female distinction from the model for simplicity. The third factor is difficult to quantify. Thus, in the present work, only the second factor, i.e., the influence of school enrollment, is considered explicitly as an endogenous variable. However, when there is a need to experiment on alternative values, this rate should be treated exogenously.

A more detailed labor force model using age and sex groups could be developed to take into specific account the changes in group labor force participation that can be expected to occur as a result of economic development.

Work hours: Work hours have been declining steadily in Japan.[37] Of the hours actually worked, overtime work shows a movement closely related to business cycles, but regular work hours has been steadily declining since 1960.[38] Work days, another factor contributing to the shortening of total work hours, have also been declining since 1960. The shortening of total monthly work hours will continue due to (1) a decline in regular work hours, (2) an increase in national holidays, (3) extra holidays on a company basis (e.g., summer holidays), and (4) a spread of five workdays a week.[39] It should be noticed, however, that the last item does not necessarily mean a decline in work hours because the latter tend to be kept unchanged by working longer hours per working day. It should also be noted that the time required for commuting have tended to get longer, especially 1960-65 period, making total hours required for work longer.

The shortening of work hours since 1960 is, in my opinion, more than incidental. I consider this trend as a form of distributing the benefit of increased productivity and is, therefore, of a lasting nature. The model includes work hours as an endogenous variable. Explicit inclusion of this variable in a production function will make it possible to obtain hypothetical output when the work hours are kept at a particular level (say, at the 1960 level).[40] For such experiments, this various should be treated as exogenous.

The share of military personnel: Use of the labor force in military service is explicitly included in the model, together with use of a portion of GNP for this purpose. In this study the amount of labor force available for other purposes is simply reduced.[41] The use of military forces for civilian purposes such as construction and flood relief is not considered. Education and technical training which military service might provide is not considered either because of data problems.

2.3.3 Technical Progress

Shift term in production function (rate of technical progress): The production functions in this study assume Hicks-neutral technical progress, which is obtained when the production function shifts over time by a uniform upward displacement of the whole function:[42]

$$Y = \alpha F(K,L), \text{ where } \alpha = \alpha(t) .$$

The index of technical change is ambiguous in economic content. Representing the summary effect on output of all forces other than changes in labor and capital inputs, the index might include the influence of purely technical changes as well as such forces as changes in scale, economic efficiency, the qualifications of labor[43] and the quality of capital.

Total factor productivity is also affected by the reallocation of factors from low-productivity to high productivity sectors. Where a certain dualism between agriculture and industry or within each sector exist, such as in Japan up to the present, intersectoral shifts eliminating or reducing these differences would be measured as improvement in technical level. The shift is a once-and-for-all change and will come to a halt when an equilibrium is attained. Rather rapid change in total productivity presumably reflects such shift taking place within a non-primary sector.[44]

Another source of the shift term is productivity change from technical change in the production process itself. One of the important factors which has made rapid technical progress possible is the existence of a large technical gap among Japan, the west European countries and the United States. In other words, Japan's technical progress has been supported by the introduction of new technology out of a large pool of advanced technology which had been accumulated during and after World War II.[45] This pool of knowledge is being exhausted. It is sometimes argued that Japanese technological progress will have to slow down in the near future because of this depletion.

The above argument would come true eventually. So long as the near future is concerned, the rate might not have to go down. Even when the gap in knowledge is eliminated, the dispersion of the knowledge and capital stock embodying such knowledge in Japan might continue for some time. If the elimination of capital rationing to less favored sectors thanks to increased availability of capital is considered, the rate might even accelerate in the short run before it finally tapers off.

Another point is that technology has to be embodied in new capital in most cases;[46] hence, a rapidly growing economy is in a better position to implement a new technology. Technological findings and their implementation have to be distinguished. As long as the Japanese economy keeps growing faster than elsewhere, new technology will be implemented in Japan on a large scale once it is developed somewhere in the world.

There are many possibilities, some of them conflicting, and one cannot draw a definite conclusion regarding the general trend in the shift term in production function, much less a specific figure. This model, as it stands, uses the figure observed in the sample period from 1950 to 1970. The estimate for the future apparently is centered around this value; if another figure is to be tested, the coefficient on time trend can be replaced by that value.

Research and development expenditures: The research and development expenditures would tend to increase for at least two reasons. First, with the virtual elimination of the technology gap which existed between Japan and Western European countries and the United States, Japan will be required to expend more effort on new technology.[47] Second, worsening environmental pollution, unavailability of land, water, and natural resources, and problems accompanying unparalleled density of economic activity would require more spending for research and development.

Our empirical knowledge does not permit us, as yet, to estimate the relation between technical progress and research and development expenditures.[48] These two items will be treated separately in the model. Although the long-run implications of research and development expenditures are totally different from military expenditure because of their direct effect on technological progress, its effect in the short-run

is very similar and can be represented as a leak from the production cycle.

The ratio of research and development expenditures to the GNP has been relatively favorable to Japan in the past compared to other major industrial countries.[49] For the reasons given above, expenditures in this field might turn into a relative burden for the Japanese economy in the near future. The share of research and development expenditures in the total GNP is treated as exogenous in the model.

2.3.4 Availability of Land, Water, and Resources

Rate of land utilization and price of land: Absolute availability of land itself is becoming a problem of major magnitude in Japan.[50] Construction of housing capital and social capital is being hampered because of the shortage of land and the accompanying increase in land prices. The rise in land price also tends to redistribute wealth in favor of the landowners and land speculators.

Limitation on the availability of land is not only a problem in itself but also an aggravation of the pollution phenomenon. Mere output of pollutant does not necessarily cause pollution. Even when it is released into the natural environment, it still would not cause the pollution phenomenon if the natural capacity to absorb such pollutant is large enough. If the density of economic activity is as high as it is in Japan, things which are not recognized elsewhere as pollutant become pollutant. Noise of highways and railways, and vibration of construction site or subways become nuisance. The right to enjoy sunshine is in serious jeopardy in residential areas as higher buildings are built, and this problem has been repeatedly fought in the courts.

Total availability of land is nearly fixed even when we consider the possibility of reclamation.[51] Actual utilization of land depends on the geographical condition of land and the demand for land. Geographical condition of land in Japan is shown below.

Area by land form[52]

Total area (km^2)	369,900
Percent by land form	
mountain	55%
volcano	6
hill land	11
piedmont	1
volcanic flank	3
upland	11
lowland	13

Actual utilization of land in 1965 is reported as follows:

Utilization of land[53]

agriculture	60,000 km^2	16.22%
forestry	251,700	68.06
fields	10,700	2.89
rivers and lakes	10,600	2.87
road	4,200	1.14
residential area	7,800	2.11
other	24,800	6.71

It should be remembered that a large percentage of Japanese land is uninhabitable and uncultivable. Some part is volcanic; most of the mountain regions are unusable for any economic purpose due to the steepness of the slope. Some part is unproductive for agricultural purposes due to its volcanic formation.[54] Against this unavailability is the increasing demand for land. This model considers the land use for non-primary, housing, and social capital as an endogenous variable. The ratio of the land used for these purposes to usable land is then calculated as the rate of land utilization, which is considered an important environmental indicator. The input of land for agricultural purposes is treated exogenously.

Rate of water utilization: There are apparently three sources by which to obtain water; (1) total precipitation, (2) recycling of water, and (3) desalination of sea water. Taken together, the absolute availability of water is not limited technically. However, at a given level of technology, additional water is made available only at a sharply increasing cost and, therefore, should be considered fixed for a period of five to ten years.

Total amount of precipitation is limited and, in Japan, small, relative to the size of population and industrial activity.[55] The amount of water useable for agricultural, industrial, household, and other purposes depends on the amount of capital invested on dams because of the steepness of land in Japan. Otherwise the water will flow into the ocean very quickly. Because of the steepness of the slope, dams of a particular size hold much less water than where the land is flat.

Recycling of water depends on cost and available technology. Direct use of salt water for industrial purposes depends on increased cost of using salt water compared with the cost of obtaining fresh water.[56] Desalination of sea water depends on technology that reduces cost from today's level and the relative cost compared to other sources of water supply.[57]

The shortage of water will be felt more keenly in the near future as industrial and household demand for water increases as a result of increased levels of production and consumption. This will have to be solved by increased social capital and/or increased research and development in the technology of desalination and recycling of water. Besides, increased use of water would mean more input of the environment to

economic activities. This model includes the rate of water utilization as one of the environmental indicators.

Availability of natural resources: As is well known, Japan lacks almost all kinds of raw materials which are indispensable for industrial production. Thus she has depended more and more on foreign resources as industrial activity has grown.[58]

Such trend will raise many problems which include:

(1) possible exhaustion of these resources;

(2) difficulty in obtaining such a large share of world resource production competing with other major consuming countries;

(3) rising price of these resources;

(4) difficulty of maintaining balance of trade with non-resource producing countries. Japan will be running a deficit against resource producing countries and surplus with non-resource producing countries if Japan remains a resource importing, products selling country;

(5) increased vulnerability of the economy to external disturbance like regional conflict which might lend to the argument of increased military power; and

(6) transporting and storing technology.

To avoid complexity, only energy sources will be considered in the model.

2.3.5 Environmental Pollution

In Japan, pollution is considered to include[59]

(1) air pollution,

(2) water pollution,

(3) soil pollution,

(4) noise and vibration,

(5) sinking of land,

(6) offensive odor,

(7) pesticides residuals, and

(8) thermal water.

Of these, the first three items are known to have resulted in human deaths and illness.[60]

The existence of pollutant and the phenomena of environmental pollution should be distinguished. Nature is considered to have the capacity to absorb output of pollutants, and only when the output level of pollutant exceeds these limits is the situation called pollution.

In this model, the absolute amount of pollutant produced in the economic system is considered first; this includes output of polluted water, output of air pollutant, and output of waste.[61]

Second, the removal rate of pollutants is taken up, namely, the dispersion rate of sewerage system and the collection rate of waste. To improve the removal rate of pollutant, more social capital (e.g., sewerage and waste collection) or more pollution prevention capital (e.g., SO_2 removal at stack) is required.[62] Where technology is not available, more research and development will be involved.

Finally the actual level of environmental pollution is considered. It is possible to include many components, but again the number will have to be limited in relation to the size of the entire model.

The level of pollution will affect population and labor supply via increased deaths and illnesses. Economic development has reduced such illness as legal infectious diseases, designated infectious diseases and tuberculosis by means of better health care, but has brought illness by means of increased pollution.

Pollution also resulted in public resentment toward economic growth in general and in public resistance to the new location of pollution producing facilities including, in particular, industrial plants, power plants, waste treatment facilities, construction of highways, railways, and airports.[63]

2.3.6 International Trade

Balance of trade: In a previous work it was found that the elasticity of export has been increasing more rapidly than the elasticity of import, implying that a shift in Japanese trade structure has occurred in such a way as to enable Japan to grow at an accelerated rate.[64]

As a result, Japan has come to suffer from chronic suprlus in balance of payment.[65] Possible solutions are:

(1) floating of the exchange rate;

(2) alternatively, continuous revaluation in order to offset the effect of structural change which reinforces income elasticity;

(3) further trade liberalization;[66]

(4) export restriction; and

(5) change in the agricultural policy.

The last point may need further explanation. Japanese agricultural policy, as in any other country, tends to be self-sufficient for important items. Thus, except for domestically unavailable products, such as wheat or sugar, import of agricultural products has been limited to short term stabilization imports. Today Japan seems to be following the policy of self-sufficiency even for items like dairy products and meat. Judging from the Japanese trade structure and very limited availability of useable

land as well as expected shortage of labor, such an agricultural policy of self-sufficiency would be untenable in the future.[69]

Exchange rate: Equilibrium of balance of trade or balance of payment can be maintained by solving the export and import functions for exchange rate (plus additional consideration for movement of capital to maintain balance of payment in equilibrium).[68] The international competitiveness of products of a particular country is dynamic and reflects the changes in productivity and relative prices of factors of production, and the invention or introduction of new products gives rise to international trade based on availability. The equilibrium exchange rate therefore alters as a result of changing relative positions of countries of the world. In the long run, therefore, the exchange rate is more than a monetary variable by which the movement of relative prices is changed. The relative stability of the world economy since the time of the Breton Woods Agreement under the superiority of U.S. economy, has allowed the exchange rate between the dollar and the yen to be maintained at the same level for the period 1949-1971. The situation seems altogether different today; thus the exchange rate will have to be altered more frequently to maintain the balance of trade. The model should be able to treat this exchange rate endogenously.

2.3.7 Density

Density itself will not be a limitation to growth technically. A distinction between density and congestion seems necessary. Density becomes a problem when it causes congestion due to lack of measures to neutralize the problems arising from high density. A high ratio of population, production, capital stock, and transportation activity to the land in which they are contained will result in small housing units,

high land prices, increased levels of pollution, increased traffic accidents, and increased frustrations in urban life.

People's tolerance for congestion will lessen as their income levels rise, whereas actual level of congestion tends to worsen more quickly than before because of increased level of production and consumption and progress of urbanization. Density will

(1) make the production more costly through the need for pollution prevention measure and research and development expenditures;

(2) make the pollution level worse which result from the level of pollutant emission into the natural environment and the relative size of the natural environment, namely land area;

(3) make the living condition less pleasant when density itself is considered a negative factor; and

(4) make it necessary to provide more social capital in order to neutralize the negative aspects of high density or congestion.

On the other hand, density is sometimes counted among the merits of industrialization and urbanization in general and of the Japanese economy in particular. It will be beneficial for the ease of communication, savings of social capital required, efficient use of specialized talent, and efficient distribution channels of commodities.

The model presented in this study includes various densities among its endogenous variables. Due to theoretical difficulty, the feedback effect which density indicators might have on the other parts of the system is not considered.

2.3.8 Speed of Social Transformation

Regional and occupational relocation: These items are more related to the maximum speed of economic growth rather than being the deterrent of it. Any organization is subject to organizational constraints when it changes its form, and a society is no exception. Economic growth and development is synonymous with social change and includes regional relocation of population, occupational relocation of the labor force, and change of use of land, among others. It takes time to move people from one area to another; it also takes time and retraining to reallocate the labor force; organizational expansion or retrenchment which is inevitable accompanying economic growth also takes time for adaptation. Training of managerial skill is a difficult task to be achieved in a short period of time and without managerial skill no organization can function properly. Thus the speed of social transformation is the ultimate upper limit of the growth rate.

A society will be more adaptable to rapid change as it develops due to a higher level of education attained under higher income and an increased demand for skilled labor. Managerial skill is accumulated among a larger percentage of the population. People's attitude is changed in favor of the change in general. An increased supply of social and housing capital would make the moving and relocation smoother. It can reasonably be assumed that the maximum speed of economic growth is higher in today's Japan than, say, 20 years ago. On the other hand, people might prefer peace and quiet over change and growth as their level of income increases.

The model includes a regional allocation function of the population. Other indicators of organizational change can be easily derived from the

main system including occupational change from primary to non-primary sector, and changes in land use, among others. The effect which the speed of social transformation indicators exerts on the other aspects of the economy is difficult to quantify and is not considered in the present model.

2.3.9 Price Stability

One major item in the speed of social transformation indicators is the change in prices. People would not adapt to changing relative price usually accompanied by the rise of general price level, even when it is an inevitable result of economic development and when the price rise is more than compensated for by the rise in income.

Despite relative stability of wholesale prices, which consists mainly of manufactured goods, consumer price has been increasing fairly rapidly in Japan. Although this does not affect international competitiveness of Japanese goods or investment decision of private business firms, this has been the prime concern of the Japanes public. It is therefore essential to know how the price indicator behaves.[69]

FOOTNOTES FOR CHAPTER 2

[1]The variables included under heading of the social and welfare indicators vary. See, for example, Adelman (1967), pp. 16-17; U.S. Department of Health, Education, and Welfare, pp. ix-x; Sheldon and Moore (1968), pp. vii-x; Kokumin Seikatsu Hakusho 1971, pp. 367-387; Rodo Hakusho 1971, pp. 193-195 and p. 478; Maruo (1971-1), p. 20; Noda, especially p. 20; and Beckerman and Bacon.

[2]Sheldon and Moore (1968), p. 10. "There are always available at least partial solutions to problems of adding unlike quantities, particularly in trend analysis. One such solution is the use of index numbers, pegged to a common temporal base, allowing the observer to sort out differential rates of change, and, perhaps, some clues to temporal priorities--which changes lead and which lag."

[3]For a list of conventional economic growth- and development-related variables, see Denison, Maddison (1970), Kaldor (1966), Brubaker (1968), Klein (1965). The limited possibility of applying conventional economic tools to less developed economies is pointed out in Seers, and his point holds for the case of Japan. Some economists stress institutional aspects (see Shinohara (1964), pp. 1-21), but this study seeks a quantitative treatment because we believe that institutional peculiarities can be better understood with quantitative knowledge. The so-called dualistic character of the economy is considered a key factor in the past Japanese development process. See, for example, Shinohara (1961); Tsujimura (1967); Tsujimura and Nishikawa (1967-1968). Our model does not consider dualism because it ceased to be a feature of the Japanese economy.

[4]See, for example, Okun and Richardson; Kuznets (1956).

[5]Some of the constraints are discussed in Ohkawa and Rosovsky (1963) and Kanamori (1971). See also Denison (1967), Maddison (1970), and Kaldor (1966). Institutional factors are not considered in the model; indirectly, however, the dissonance in the system can be measured using the model and would give good indication of political stability (or lack of it) in Japan in the years to come. For anticipated policy change, see, for example, Keizai Hakusho 1971, pp. 96-101; Kensetsu Hakusho 1971, pp. 3-4.

[6]Klein (1965).

[7]For international comparisons, see Emi and Mizoguchi, pp. 8-9 and Chapter 2.

[8]For typical hypotheses explaining the high rates, see Shinohara (1964), pp. 63-89; Komiya (1963), pp. 157-158.

[9]Kurihara (1971), pp. 26-27. The concentration on personal saving rate is justified by the weight household sector carries in total saving and by the fact that it is the only net saver in the Japanese economy.

[10]For empirical data on financial assets for 1963-1970 period, see Kokumin Seikatsu Hakusho 1971, p. 62.

[11]Shinohara (1969), p. 265.

[12]Emi and Mizoguchi test hypotheses concerning Japanese saving rates, including (1) the role of a particular occupational group, (2) fluctuating income due to bonus system, (3) high ratio of the self-employed, (4) disequality of income distribution, (5) the effect of age composition of population, (6) Pigou effect, (7) incomplete social security, and (8) traditional saving psychology. Their conclusion is that the main factor is the high growth rate of income, supplemented by the effect of biannual bonus system and underdeveloped consumer financing. See pp. 87-111. Their international comparisons in Chapter 2 also point to the role of growth term. See also Shinohara (1969), p. 265, Ohkawa (1970), and Emi (1969).

[13]For example, dependency rates are said to explain differences in savings rates. See Leff. Asset effect is another example. Emi and Mizoguchi, pp. 72-74. Interesting observations on savings in Japan is presented in Kokumin Seikatsu Hakusho 1971, pp. 54-55. The same source gives data on financial assets. See pp. 62-64.

[14]For a definition of social overhead capital, Kurihara (1971), p. 45. "Social overhead capital generally means that part of the total stock of capital which owes its origin and existence to the public interest at large and which has no direct bearing on the productive process." He adds, "the pedagogic question of what specific items are to fall in the conceptual category of social overhead capital could be answered variously, depending on the analytical purpose and value judgment of the pedagogue." Also see Colm, p. 30, for definitions of "productive" capital.

[15]For distribution of government investment by purposes for 1961-1971 (planned), see Hashimoto, p. 33. Shin Keizai Shakai Hatten Keikaku, p. 121, gives a breakdown for 1964-69, 1967-1971, and 1970-1975. Hashimoto shows, based on government figures, that the ratio of government capital to GNP declined from 1.95 in 1955 to 1.29 in 1963 (p. 34). The general trend is also observed in Shin Keizai Shakai Hatten Keikaku, p. 122.

The gap has been noticed for quite some time. See, for example, Shinohara and Uchida, Vol. 1, pp. 151-178 which was published in 1962. Official view blames the underestimation of private investment in government economic plans for causing such a gap. For example, the Economic Deliberation Committee states, "Since economic growth rate exceeded the planned level, government policies based on the under-estimated national economy tended to fail to achieve planned values when looked upon as the ratio to national income or private investment in machinery and equipment." See Nihonno Keizai Keikaku, p. 7. Tsuru (1970), pp. 163-169, attributes such failure as inherent to market economy. See also Takeuchi for a general discussion and Hiroshi Kato (1969) for a review of recent works in this field.

For theoretical rationalization of the policy of deliberately creating a gap between directly productive capital and social overhead capital, see Hirschman, pp. 83-97.

There is no objective basis for the optimal amount of social capital stock. International comparisons in Keizai Hakusho 1971, p. 98 and Tsusho Hakusho 1971, p. 100, might be helpful.

[16]For an official view on future plans, see Hatoyama, especially pp. 3-9. The absolute magnitude of general government capital formation is second to U.S. and its ratio to GNP is among the highest among industrial countries. The following table is extracted from his article.

GNP and general government fixed capital formation (1968)
(in billions of yen)

	A. GNP (current)	av. growth '60-'68	B. Gov't fixed investment (current)	av. growth '60-'68	B/A
Japan	51,148	15.9%	2,420	17.3%	4.7%
U.S.	317,088	7.0	8,316	8.0	2.6
U.K.	37,065	6.6	1,050	14.6	2.8
W. Germany	47,772	7.5	1,845	9.8	3.9

[17]See, for example, Emergency Act for Waste Treatment Facilities Construction and accompanying Four Year Plan for Waste Treatment Facilities Construction (1972-1975), as reported in Nihon Keizai Shinbun, March 14, 1972.

[18]Kensetsu Hakusho 1971, p. 66, points out that "the harms of excessive density are mainly caused by the relative level of social capital. It follows, therefore, that these problems are expected to be solved to a considerable extent by additional construction and improvement of streets and highways, parks, housing, sewerage, river, and other facilities."

[19]See Keizai Kikakucho Chosakyoku (July 1971).

[20]Odaka gives international comparisons of the quality of housing capital. See Odaka (1971).

[21] On the national average, floor area per person increased 25 percent during 1958-1968 period. Kensetsu Hakusho 1971, p. 24. For housing problem in Japan, see Iwai, et al., and Nakazawa, et al. For international comparisons of housing construction, see U.N. Statistical Yearbook.

[22] See A. M Okun; and The Council of Economic Advisors.

[23] Japan's figure for 1972 stood at 0.9 percent. This can be compared to 6.3 percent for total OECD countries and 9.0 percent for the United States (both in 1968). See Tsusho Hakusho 1971, pp. 146-147. For the share of military expenditure in government expenditure, see Hatoyama, p. 1.

[24] Kurihara (1971), pp. 7-13, for example, evaluates the military expenditure in this line.

[25] Nihon Keizai Shinbun, February 25, 1972; the figures are based on a survey by the Ministry of International Trade and Industry. Production statistics of pollution prevention equipment is as follows, according to Japan Industrial Machinery Industry Association as reported in Tsusho Hakusho 1971, p. 106 and Nihon Keizai Shinbun, July 26, 1972 (in millions of yen).

	Fiscal Year				
Item	1967	1968	1969	1970	1971
air pollution	26682	39211	73558	84242	124651
water	22026	26161	54806	88598	140325
waste	6231	11462	14391	21105	34487
noise & vibration				648	805
total	54939	76834	142756	194593	300268

[26] For the text, see Wagatsuma, pp. 1207-1234.

[27] Although international comparisons are not feasible at this time, it is important to obtain corresponding figures for other industrial countries. This knowledge may clarify the allegation that Japanese firms have sabotaged pollution prevention in Japan making it possible for them to lower export prices. Also this would enable us to see whether this item is a relative burden to Japan. U.S. figures are by McGraw Hill, Swedish figures by the Ministry of Finance, and Japanese data by the Ministry of International Trade and Industry, all of which are reported in Nihon Keizai Shinbun, February 25, 1972.

	Total manufacturing	Steel	Paper & pulp	Petroleum refinery	Non-ferrous metal	Chemical
Japan '70	5.3	6.2	6.1	10.1	7.8	4.1
" '71	9.1	10.0	14.2	14.1	12.1	7.6
" '72 (planned)	11.5	10.4	17.8	15.5	14.8	12.6
U.S. '70	5.4	10.3	9.3	6.0	na	na
Sweden	na	6.3	5.1	na	5.4	6.3

[28] Job openings and applicants (ratio of openings to job seekers)

	Junior high school graduates	Senior high school graduates
1958	1.2	1.1
1959	1.2	1.1
1960	1.9	1.5
1961	2.7	2.0
1962	2.9	2.7
1963	2.6	2.7
1964	3.6	4.0
1965	3.7	3.5
1966	2.9	2.6
1967	3.4	3.1
1968	4.4	4.4
1969	4.8	5.7
1970	5.8	7.1

Source: Labor White Paper 1971, p. 153.

[29] See, for example, Leff.

[30] For the actual and predicted figures on age composition of the Japanese population for 1920-2000, see Kuroda (1971). See also Hama and Yamamoto for the dependency rates by six age groups for 1930-1985.

[31] See, for example, Tachi and Yamaguchi (1970), pp. 6-9.

[32] For a comprehensive framework of labor force participation analysis, see Bowen and Finegan. For Japanese data, see Showa 40-nen Kokusei Chosa Hokoku dai 3 kan Zenkokuhen Sono 1.

[33] Rodoryoku Chosa Tokubetsu Chosa Hokoku (1969), pp. 6-7, indicates close correspondence between labor force participation rate and school enrollment rate for ages 15-19.

[34] Rodo Hakusho 1971, p. 482.

[35]See Sakamoto (1963) for relation between industrial growth and enrollment. A marked decline in the labor force participation among schooling age population is shown below. Data is from Rodo Hakusho 1971, p. 169. This points to the need for developing a labor force sub-model by age and sex.

Transition of labor force participation rate by sex and age (%)

male	1962	1963	1964	1965	1966	1967	1968	1969	1970
15-19	46.7	42.4	37.3	36.3	37.9	36.9	37.0	33.7	31.4
20-24	87.1	86.1	85.8	85.8	85.7	83.6	82.2	80.4	80.5
25-64	95.1	94.9	95.0	95.1	95.2	95.3	95.9	95.9	95.7
65-	57.9	56.4	56.3	56.3	56.2	54.5	52.1	51.3	49.4
total	84.3	83.1	82.1	81.7	81.7	81.6	82.1	81.9	81.8
female									
15-19	46.8	41.9	37.4	35.8	38.0	38.8	38.1	35.0	33.6
20-25	72.5	71.9	70.7	70.2	70.1	70.0	70.1	70.0	70.5
25-29	52.3	50.7	49.4	49.0	48.7	49.2	48.0	47.0	45.6
30-39	56.7	56.0	55.6	55.3	54.7	54.4	53.9	53.2	52.8
40-64	55.3	55.0	55.3	55.6	56.6	57.0	56.8	56.6	56.3
65-	22.8	21.9	22.3	21.6	21.7	21.6	18.9	18.5	18.0
total	53.4	52.0	51.1	50.6	50.9	51.2	50.7	50.1	49.9

[36]Obi (1968), Nishikawa (1970), Nakano (1969) (1970) (1971). For female labor statistics, see Jinko Mondai Kenkyujo (1969).

[37]International comparisons show that Japanese working hours are longer than in other major industrialized countries. Data from Ministry of Labor (1971). Figures are for 1970 (1969 for Italy).

Average weekly work hours including holidays			Work hours in normal week		Daily work hours		
Hours:							
Japan	U.S.	Germany	Japan	U.K.	France	Japan	Italy
43.1	37.5	39.1	45.0	41.5	43.1	8.34	7.83
Index:	(Japan = 100)						
100	87.0	90.7		92.2	95.8		93.9

[38]Rodo Hakusho 1971, p. 160, gives the following figures for monthly average working days:

1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
23.9	23.9	23.8	23.7	23.6	23.5	23.5	23.4	23.1	22.9

[39]Keizai Kikakucho Chosakyoku, June 1972, pp. 25-51. See also Nihon Keizai Shinbun, February 2, 1972; April 16, 1972; and May 17, 1972.

[40]According to the Ministry of Labor (1972), shortening of work hours increases labor productivity. If this proves to be true in the long run, observed shortening of work hours might have had positive effect on output. This would preclude the simple calculation of labor input as indicated here.

[41]International comparisons reveal the advantage which Japan enjoyed during the period under consideration. The percentage of military personnel in total employment in major industrial countries is given in Denison, p. 71, which is as follows.

Percentage of military personnel, 1960	
United States	3.6
Northwest Europe	2.4
Belgium	3.2
Denmark	2.3
France	4.3
Germany	1.1
Netherlands	3.1
Norway	3.0
United Kingdom	2.1
Italy	1.8

The Japanese figure was 0.6% in 1960; the figure remained the same in 1970.

[42]R. G. D. Allen (1968), pp. 239-240. See also Tsujimura and Watanabe (1966); and Amano (1968) for theoretical review.

[43]This includes formal education and "learning by doing." See Arrow (1962).

[44]See Balassa (1964). Massell tries to separate out such shift within non-primary sector. See also Ohkawa (1967), and Watanabe and Egaitsu for the case in Japan.

[45]K. Sato argues that the growth of total factor productivity was moderate for the period 1946-1958 and that the acceleration since 1958 is caused by the introduction and spread of high productivity labor saving technology which began when the unlimited supply of labor came to an end. He adds that such discontinuous technical progress was made possible by the import of advanced technology.

[46]As an example of inclusion of capital's age in an empirical work, see Brubaker (1968).

[47]Iinuma suggests the concept of technological substitution point after which domestic creativity is required. His conclusion is that today's level of Japanese technology is approximately at the point of technological substitution.

[48]For review of recent literature on endogenous treatment of technical progress, see Kiyokawa.

[49]Tsusho Hakusho 1971, p. 403, gives international comparisons of research and development effort of major countries in 1967.

	R & D expenditure			
	million dollars	rate of increase '64-'67	per capita dollar	share of GNP
Japan	1684	17.2%	16.9	1.5%
U.S.	23613	3.9	114.0	3.0
U.K.	2480	4.7	44.9	2.3
W. Germany	2084	13.5	34.8	1.7

[50]See, for example, Kensetsu Hakusho 1971, p. 46 ff. The shortage is typically witnessed by the fact that 13 percent of the New Tokaido Trunk Line and 35 percent of the Sanyo Trunk Line (both of Japan National Railways) are tunnels.

[51]There are three possible ways to "produce" land space: (1) underground, (2) reclamation of sea, and (3) artificial land. Total reclamation of sea since 1954 to 1969 amounts to 280 km^2, of which 246 km^2 is for industrial purpose and 34 km^2 for urban development. See Kensetsu Hakusho 1971, p. 14. Artificial land is becoming popular as a measure of urban development. See, for example, Nihon Keizai Shinbun, January 3, 1972.

[52]Japan Statistical Yearbook, 1968, p. 203.

[53]Kensetsu Hakusho 1971, p. 46.

[54]The fact that development of virgin land following World War II was done in order to absorb the unemployed and to promote the production of food, but was later abandoned in most places tells us that the land under cultivation in Japan at present is very close to the maximum.

[55]Kensetsu Hakusho 1971, p. 51 gives the following figures.

	Annual precipitation mm	Total hillion m^3	Per capita m^3/year
Japan	1818	670	6610
U.S.	833	7800	39200
World	730	108400	32000

[56]For recycling of industrial water, see Kogyo Tokeihyo Yochi-Yosuihen, various years. It is suggested that one third of household water can be recycled. Nihon Keizai Shinbun, July 2, 1972.

[57]The cost of desalination is 100 to 150 yen per ton at present, compared to 50 yen for water obtained by building dams. The cost difference is predicted to disappear by 1985. Nihon Keizai Shinbun, April 21, 1972.

[58]See Imai for Japan's energy problem. Tsusho Hakusho 1971, pp. 334-463 deals with resource problems in Japan. See also ibid., p. 455. The following table summarizes the point. Source: Ibid., p. 338.

	Imported share (%)		
Item	1963	1969	1975
1. copper	59	72	82
2. lead	51	55	46
3. zinc	23	49	57
4. aluminum	100	100	100
5. nickel	100	100	100
6. iron ore	76	86	91
7. coking coal	47	78	92
8. petroleum	99	99	100
9. uranium	--	100	100
10. lumber	25	46	49-58

[59]Kogai Hakusho 1971, pp. 7-9.

[60]Air pollution: Photochemical smog is occurring repeatedly in urban areas since 1970. Yokkaichi City has had 800 asthma patients officially recognized as pollution victims as of January 1972. Fifty-eight of them have died (Nihon Keizai Shinbun, January 30, 1972). Fuji City has 335 patients, six of whom are in serious condition and one death has been reported (Nihon Keizai Shinbun, June 29, 1972). Asthma cases are wide-spread among school children; Tokyo reports 3.1%, Fuji City 2.19%, and Chiba City 2.45%, as compared to 1.0% in non-polluted areas (Nihon Keizai Shinbun, May 27, 1972).

Water pollution: Mercury poisoning in Minamata Bay resulted in 292 recognized cases, of which 59 were fatalities, and an additional 405 patients are waiting confirmation (Asahi Shinbun, October 6, 1972). Total number of patients could reach 20,000 to 30,000 (Nihon Keizai Shinbun, February 22, 1972). Mercury poisoning along Aganogawa River resulted in 49 patients, six of whom died as of February 1971. Cadmium pollution in Toyama Pref. so far resulted in 122 cases, of which 28 were fatal. There are seven other polluted areas under surveillance. See Kogai Hakusho 1971, p. 98.

Soil pollution: Sixteen suspected patients due to PCB pollution were found (Nihon Keizai Shinbun, July 22, 1972).

[61]For economic effect of lowering sulphur content of fuel oil, see Osawa, Uchida, and Saito.

[62] An estimate of social cost due to environmental pollution is given in Kankyo Hakusho 1972. The cost increased seven times in 1960-1970 period.

[63] For the present situation of pollution and pollution control, see Kogai Hakusho 1971; Kankyo Hakusho 1972; Tsuru (1970); Tachi and Kato. For pollution control laws, see Wagatsuma, pp. 1207-1234.

[64] Uno (1971-4). See also Vernon; Sazanami, Chapters 3, 4, and 5; Kanamori (1963); Negishi and Watanabe (1971). For the Japanese trade policy, see F. Watanabe. For the relation of technological progress and trade, see Posner. His argument is that comparative advantage is caused by differences in the distribution of investment between industries.

[65] The transition of Japan's balance of trade position is summarized in Keizai Hakusho 1971, p. 94, and is shown below. (annual average, million dollars)

	1946-52	1953-57	1958-64	1965-70	1970
balance of trade	-233	-360	151	2588	4469
export	661	2041	4480	12601	19878
import	894	2401	4329	10013	15409
changes in reserves	143	-58	211	400	1599

[66] Remaining import restrictions as reported by respective governments to GATT are as follows (Keizai Hakusho 1971, data appendix p. 11).

	Global			Discrimination against Japan		
	total	agri-cultural goods	manu-factured goods	total	agri-cultural goods	manu-factured goods
France	74	39	35	44	17	27
W. Germany	39	19	20	21	1	20
Italy	20	12	8	46	2	44
Benelux	14	10	4	27	0	27
Britain	25	19	6			
U.S.	5	1	4			
Canada	5	4	1			
Japan	40	28	12 (as of Sept. 1971)			

[67] As an example of such policy, see a draft plan prepared by Liberal Democratic Party Comprehensive Agricultural Policy Study Committee as reported in Nihon Keizai Shinbun, October 10, 1971.

[68] For the concept of balance of payments equilibrium, see Kindleberger (1969). For optimal amount of international reserves, see Heller; Clark; Kelly. For various proposals for exchange rate adjustment, IMF (1970). Also see Alexander; Clement, Chapters 5, 6, and 7.

[69] For theoretical and empirical relation between the rate of economic growth and consumer price hike, see Maruo (1971-2).

CHAPTER 3

STRUCTURE OF THE MODEL

The topic in this chapter is the specification of individual equations and their interdependence in the system. The model is so designed as to enable the analysis of the points listed in Chapter 2. In this chapter the equations are placed into several groups according to the aspects of the economy which they cover. Finally, the flow of the entire model is shown.

For policy simulation purposes, variables in question must be treated as exogenous variables; it is not desirable, however, to make all possible candidates for policy simulation exogenous because this would make the model mainly determined by exogenous forces, with the result that the model itself would explain virtually nothing at all. Therefore, at the initial stage, as many variables as possible are treated as endogenous. The present model is self-determining once the initial conditions and a small number of exogenous variables are input into the system.

After the structure is estimated and the reliability of the model is confirmed, we will be able to treat some of the endogenous variables as policy variables and thus exogenously, giving them experimental values. However, the purpose of the present study is to build and test the basic model; policy simulation is outside the scope of the present paper.

3.1 The Method of Estimation

The estimation of structural parameters is done by ordinary least-squares. This is justified by the argument that for small samples,

ordinary least-squares estimation often retains a minimum variance property. In other words, the small sample variance of the ordinary least-squares estimators may be smaller than the variance of 2SLS estimators, and the variance of the former may be sufficiently small to compensate for their bias.[1]

The number of predetermined variables in the present model exceeds the number of sample observations (21), from 1950 to 1970. This causes the problem of undersized samples. The observation matrix of the predetermined variables X cannot have a rank larger than sample size n, and X fails to have full column rank when the total number of predetermined variables exceeds the sample size n. This implies that the 2SLS estimators do not exist, since they require the inverse of X'X. This problem may be solved by the use of principal components of predetermined variables or by causal ordering of the model.[2] In this study this problem is avoided altogether by justifying the use of OLS.

In this study, equations are specified in a log-linear form, considering both the nonlinearity in the system and the ease of simulation analysis. In general, a macro-economic model will become a non-linear simultaneous equation system when we consider the nonlinearity and the simultaneity in the actual economic behavior. For example, explicit introduction of the price deflators into the model would inevitably lead to nonlinearity. On the other hand, nonlinearity in the system should be avoided as much as possible in order to carry out simulation analysis and make inference into the dynamic characteristics of the system.

One of the ways to solve a nonlinear system is a linear approximation by Taylor's expansion.[3] This method would result in different

outcomes when different variables are chosen for the expansion. Another method is to solve a nonlinear system by computer iteration method.[4] Although this method has much to be recommended, it introduces added complexity when the system of equations is simulated.

The use of log-linear specification has the advantage that it allows non-linear variables to be rewritten into easily tractable linear relations, because multiplications appear as additions and divisions as subtractions. Then the structural form may be written as

$$Y\hat{\Gamma} + X\hat{B}$$

where $\hat{\Gamma}$ is the $M \times M$ matrix of estimated coefficients of jointly dependent variables, each column referring to a single equation: $\hat{B}$ is the $K \times M$ matrix of estimated coefficients of the predetermined variables, each column referring to a single equation; Y is the $T \times M$ matrix of observations on the jointly dependent variables; and X is the $T \times K$ matrix of observations on the predetermined variables.[5]

There are other advantages in using log-linear specification. First, the Japanese economy has been growing at an almost constant rate and this is expected to continue for sometime. A log-linear specification is suitable for treating variables which are growing at a constant rate. Second, structural parameters in log-linear equations represent elasticity with respect to those variables. This elasticity is of interest itself. Further, this will enable us to avoid the difficulty involved in the differences in the measuring units, since the elasticity is defined in terms of proportional changes which are necessarily independent of units.[6]

One problem in using a log-linear specification is the treatment of definitions and identities. In the present study, a logarithmic

approximation of identity is used, which takes the form of a weighted arithmetic mean.[7] Natural choice of the weights would be those of the mid-year of our sample observation if our purpose is to reproduce the past. In this study, however, 1965 weights are used so that, when simulated for the future, the error resulting from the use of fixed weights could be minimized.

3.2 List of Variables

Note: exogenous variables are indicated by #.

#	A*	Total habitable land (km^2).
#	A1	Sown area (km^2).
	A2hs	Land used for non-primary industry, housing capital and social capital (km^2).
	a	Rate of land utilization.
	ad	Man years lost due to infectious diseases (ratio to total man years).
	ai	Man years lost due to industrial accidents (ratio to total man years).
	at	Man years lost due to traffic accidents (ratio to total man years).
	(az)	Man years lost due to diseases caused by environmental pollution (ratio to total man years).
	B	Balance of trade, defined as $B = \frac{X \cdot Px \cdot x}{M \cdot Pm \cdot x}$.
	b	Birth rate.
	Cc	Consumption of non-durable consumer goods (1965 prices) (billion yen).
	Cd	Consumption of durable consumer goods (1965 prices) (billion yen).

	Cf	Consumption of food (1965 prices) (billion yen).
#	c	Share of social capital stock for final use.
#	D1	Dummy variable; zero for 1950-1957 and unity for 1958-1970.
#	D2	Dummy variable; unity for 1966, zero otherwise.
#	D4	Dummy variable; zero for 1950-1960 and unity for 1961-1970.
#	D5	Dummy variable; zero for 1950-1954 and unity for 1955-1970.
#	D6	Dummy variable; zero for 1950-1965 and unity for 1966-1970.
#	D8	Dummy variable; zero for 1950-1969 and unity for 1970 on.
	da	Death rate (other than infants).
	db	Infant death rate.
	E	Number of people 15 years of age and older attending educational institutions (thousands).
#	e	Net emigration rate.
	EC	Energy consumption (10^{10} Kcal).
	H	Work hours in non-primary sector (monthly).
	I1	Primary sector capital formation (1965 prices) (billion yen).
	I2	Non-primary sector capital formation (1965 prices) (billion yen).
	Ih	Housing capital formation (1965 prices) (billion yen).
	Is	Social capital formation (1965 prices) (billion yen).
	Iz	Pollution prevention investment (1965 prices) (billion yen).
#	i	Imputed users' benefit rate; assumed to be 10 percent.
	K1	Capital stock in primary sector (1965 prices) (billion yen).
	K2	Capital stock in non-primary sector (1965 prices) (billion yen).

	Kh	Housing capital stock (1965 prices) (billion yen).
	Ks	Social capital stock (1965 prices) (billion yen).
	Kz	Pollution prevention capital stock (1965 prices) (billion yen).
	KD	Capital stock density.
	L	Total labor force (thousands).
	L1	Primary sector labor force (thousands).
	L2	Non-primary sector labor force (thousands).
	L2*	Non-primary sector labor force net of unemployment, military personnel, and absence from work due to labor disputes, infectious diseases, industrial accidents, traffic accidents, or by imprisonment (thousands).
	L2e	Non-primary sector labor force employed (thousands); L2e = L2·(1-u).
	L2u	Non-primary sector labor force unemployed (thousands); L2u = L2·u.
	LE	Life expectancy, average of male and female (years).
#	l	Man years lost due to labor disputes (ratio to total man years).
	M	Imports (current prices) (billion yen).
	MB	Material benefit (1965 prices) (billion yen).
#	m	Military personnel (ratio to non-primary labor force).
	N	Total population (thousands).
	N*	Population 15 years of age or older (thousands).
	ND	Population density.
	P	General wholesale price index (1965 = 100).
	P1	Primary products price index (1965 = 100).

	P2	Non-primary products price index (1965 = 100).
	Pa	Land price index (1965 = 100).
	Pc	Consumer price index (1965 = 100).
#	Pm	Import price for Japan (unit value index) (1965 = 100).
#	Pmr	Import raw material price for Japan (unit value index) (1965 = 100).
	Ps	Service price index (1965 = 100).
#	Pw	World export price (unit value index) (1965 = 100).
	Px	Japanese export price (unit value index) (1965 = 100).
	Q1	Primary sector output (index; 1965 = 100).
	Q2	Non-primary sector output (index; 1965 = 100).
	Rkh	Housing capital removal (1965 prices) (billion yen).
#	Rkh'	Housing capital damaged (1965 prices) (billion yen).
	RR	Regional relocation of population, interprfectural (percent).
#	r	Rate of capacity utilization in non-primary sector.
	S	Savings excluding changes in inventory (current prices) (billion yen).
	TA	Transportation activities, total of freight ton-km and passenger-km (millions).
	TD	Transportation activity density.
#	T	Time trend (1950 as 1).
	u	Unemployment rate in non-primary sector.
	v	Imprisonment rate among population 15 years of age and older.
	W2	Compensation of employees in non-primary sector (current prices) (billion yen).
#	W	Total precipitation (million m^3/year).

	w	Rate of water utilization.
	wmv	Share of motor vehicles in transportation activities.
	wpc	Share of petroleum and coal energy in total energy consumption.
	X	Exports (current prices) (billion yen).
	x	Exchange rate, price of yen in terms of U.S. dollar.
	Y	Gross national product (current prices) (billion yen).
	Yindex	Gross national product index (1965 = 1.00).
	Y*	Gross national product net of military expenditure and research and development expenditure (current prices) (billion yen).
	Y1	Value added in primary sector (current prices (index; 1965 = 1.00).
	Y2	Value added in non-primary sector (current prices) (index; 1965 = 1.00).
	YD	Production density.
#	YM	Military expenditure (current prices) (billion yen).
#	YRD	Research and development expenditures (current prices) (billion yen).
#	Yw	World gross domestic product (current prices) (1965 = 100).
	(Z)	(Level of environmental pollution).
	Zair	Output of air pollutant, consumption of sulphur containing resources (1000 tons/year).
	ZBOD	Water pollution level, biological oxygen demand (ppm).
	ZCO	Air pollution level, CO (ppm).
#	Zs	Sulphur contents in fuels (percent).
	ZSO2	Air pollution level, SO_2 (pphm).

Zwaste	Output of waste (1000 tons/year).
Zwater	Input of water to various activities other than agriculture = output of polluted water (million m^3/year).
zwaste	Waste collection rate.
zwater	Water pollutant removal rate (sewerage diffusion rate).

3.3 Structure of the Model

In this section, the functional forms of individual equations are explained, alternative forms are discussed, if any, the most preferred ones are picked up, and some of the empirical findings are pointed out. The results of least-square fitting are shown in Tables 3.1 through 3.10. The format of each table is standardized so as to show one equation form per line. The columns labeled b_1 to at most b_4 contain the estimated coefficients of the variables appearing at the head of the column. The *a priori* sign of the coefficient is shown for each variable. The column labeled intercept contain the estimated constant term. Standard errors and t ratios of regression coefficients as well as of constant terms are shown in parentheses.

The tables also include the multiple correlation coefficient R, the F ratio and the degrees of freedom for numerator and denominator, the Durbin-Watson statistic, and the standard error of estimate, S. When more than one functional form is listed, the first one reported is the most preferred. Coefficients are reported to five digits to keep utmost accuracy in obtaining reduced form coefficients, but their accuracy should be judged from the accuracy of the original data used in the calculation, which are different cases by case. The coefficients marked by * were obtained by extraneous estimation.

3.3.1 Production

Production functions include equations #1 and #2. See Figure 3-1 and Table 3-1.

Throughout this model it is assumed that supply capacity, rather than effective demand, limits the growth potential.[8] The model focuses on the production side rather than on the effective demand side as is usually the case for a Keynesian-type model, since deficient supply rather than deficient demand is the prime concern in the development process. Supply-demand equilibrium is ignored on the assumption that it is always guaranteed by appropriate policy measures. In the present model, therefore, the production function is of strategic importance in deciding the long-term performance of the economy. Supply capacity can be predicted or planned approximately as the extrapolation of the recent past based on the fact that it has been growing following a relatively stable path. The growth of the capacity is accounted for mainly by the supply of labor, accumulation of investment in machinery and equipment, and technical progress. Its analysis requires, therefore, a detailed study on labor force, work hours, trends of machinery and equipment investment, and technical progress, among other things.

The economy is divided into two sectors, primary and non-primary, in order to be able to analyze the structural change within the economy as it develops and yet to be able to keep the size of the model as small as possible. The Cobb-Douglas type function is used for both sectors with homogeneity of degree one, and technological progress of the Hicks type.[9] It is possible to use CES or VES function which has more general assumption about the elasticity of substitution. There is evidence that assumptions about the elasticity of substitution do make a notable

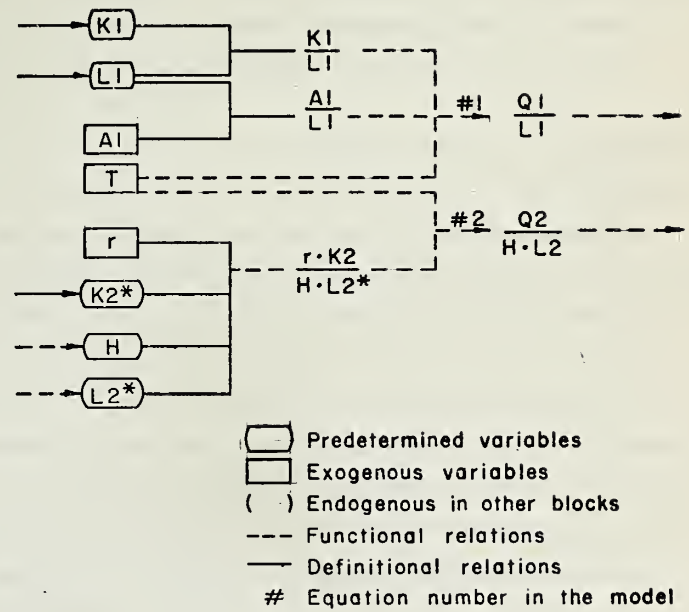

Figure 3.1. Flow Diagram of Production Functions

Table 3-1

Production Functions

	b_1	b_2	b_3	intercept	R	F	D.W.
#1. Production function for primary sector							
a priori sign	+	+	+				
$\log \frac{Q1}{L1}$	$\log \frac{K1}{L1}$	$\log \frac{A1}{L1}$	T				
1.	0.16838#	0.34308#	0.017185	-2.5290	0.9788	434.72	1.380
s			(0.00082424)	(0.010350)		1 & 19	
t			(20.850)	(-244.359)	S=0.022872		
2.	-0.058571	0.40674	0.022162	-2.3159	0.9953	610.65	2.144
s	(0.13736)	(0.66931)	(0.004942)	(0.25424)		3 & 17	
t	(-0.426)	(0.607)	(4.484)	(-9.109)	S=0.016214		
#2. Production function for non-primary sector							
a priori sign	+	+					
$\log \frac{Q2}{H \cdot L2*}$	$\log \frac{r \cdot K2*}{H \cdot L2*}$	T					
	0.34697	0.033607		-4.5992	0.9966	1345.73	1.074
s	(0.055318)	(0.0011509)		(0.13444)		2 & 18	
t	(6.272)	(29.200)		(-34.209)	S=0.021035		

difference in the share of growth regarded as accounted for by combined inputs of capital and labor as opposed to other factors.[10] However, the estimation procedure of CES function with technical change is very complicated unless marginal productivity theory is assumed to hold. In this study, the Cobb-Douglas function is chosen for the simplicity of estimation.[11]

Figure 3.1 shows the flow of production functions. The production index, and not value added, is used as the output.[12] This is expected to facilitate extension of the model by industrial branches because detailed production statistics are available by industrial branches whereas value added statistics are not. As factors of production, labor and capital are considered. In addition, sown area is used as one of the inputs in the production function for the primary sector due to the importance of agriculture in the primary sector in Japan. No adjustment is made for disguised unemployment in the primary sector.[13] For the non-primary sector, adjustment is made for the utilization rate of capital and hours worked. Assumption of homogeneity of degree one permits us to write the functions in the form that per capita capital stock (and per capita land in the case of the primary sector) determines per capita output. Non-primary output is the production index of manufacturing, mining, and utility industry whereas non-primary labor force refers to all of non-primary labor force including tertiary. This difference in coverage is rationalized by assuming that both secondary and tertiary labor forces are engaged in the production of non-primary goods directly or indirectly.

In the production function for the primary sector, the coefficients on capital and sown area are obtained by extraneous estimation.[14] This

method was adopted because direct estimation resulted in wrong sign of the coefficient on capital and insignificant coefficient on sown area (see equation #2). Estimated in this model are the constant term and the shift term of the function.

According to the estimates, the production elasticity of capital in the non-primary sector is more than twice as large as that of the primary sector, amounting to 0.346 as compared to 0.168. This value agrees with the one estimated in Economic Planning Agency Long-Term Model II (0.336) and Ueno Model III (0.402 for textile industry and 0.317 for heavy industry).[15] The shift term is also twice as large in the non-primary sector (primary sector 0.017 and non-primary sector 0.033), which compares with the values in EPA Long-Term Model II (0.039 and 0.041) and Ueno Model III (primary sector 0.012, textile industry 0.023, and heavy industry 0.035).[16]

3.3.2 Prices and Wages

The model has a wage determination equation, five price determination equations, and two definitions. See equations #3 through #10, Figure 3-2 and Table 3-2. Wage rate in non-primary sector is determined by the labor productivity in that sector.[17]

Primary products price is explained by the non-primary wage rate and lagged primary products price. The relation between the non-primary wage rate and the primary product price reflects the income compensation policy of the Japanese government. The government has been trying to protect the primary sector labor force from the competitive wave of the rest of the economy by guaranteeing a parity of their income in order to guarantee self sufficiency of agricultural products, which has been a policy goal in itself and from balance of payment considerations. This

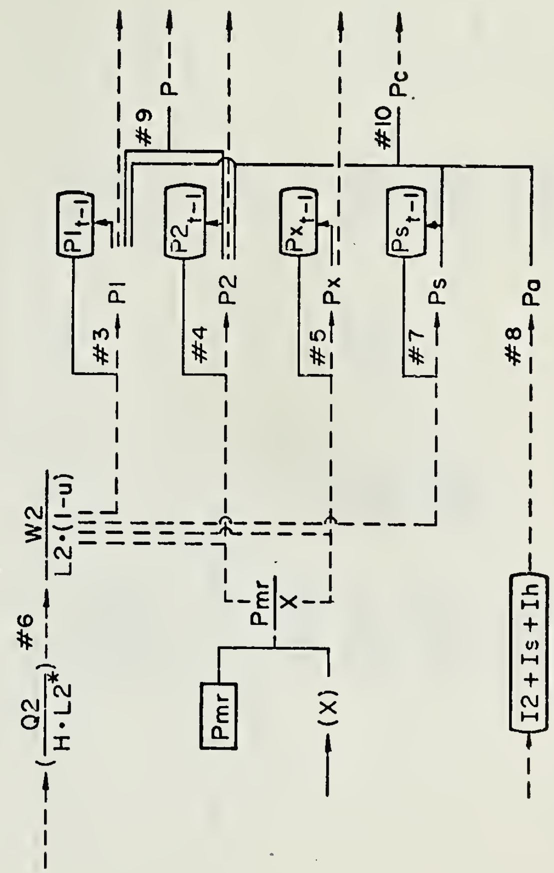

Figure 3-2. Flow Diagram of Prices and Wages Equations

Table 3-2

Prices and Wages

	b_1	b_2	b_3	intercept	R	F	D.W.
#3. Primary products price index							
a priori sign	+	+					
log P1	$\log \frac{W2}{L2\cdot(1-u)}$	$\log P1_{t-1}$					
1.	0.16400	0.45707		1.1688	0.9730	159.91	1.789
s	(0.053772)	(0.16327)		(0.34768)		2 & 18	
t	(3.050)	(2.799)		(3.361)	S=0.021814		
2.	0.30649			2.1415	0.9610	229.43	0.876
s	(0.020234)			(0.013928)		1 & 19	
t	(15.147)			(153.753)	S=0.025438		
#4. Non-primary products price index							
a priori sign	+	+	+				
log P2	$\log \frac{W2}{L2\cdot(1-u)}$	$\log \frac{Pmr}{x}$	$\log P2_{t-1}$				
1.	0.092388	0.50667	0.40433	0.21849	0.9378	41.35	2.223
s	(0.018552)	(0.084611)	(0.054780)	(0.18994)		3 & 17	
t	(4.980)	(5.988)	(7.381)	(1.150)	S=0.013084		
2.	0.14352	0.56996		0.92576	0.7023	8.76	0.692
s	(0.034295)	(0.16774)		(0.32680)		2 & 18	
t	(4.185)	(3.397)		(2.832)	S=0.026073		

Table 3-2 (continued)

	b_1	b_2	b_3	intercept	R	F	D.W.
3.	0.050724			2.0351	0.4102	3.84	1.234
s	(0.025866)			(0.017810)		1 & 19	
t	(1.961)			(114.267)	S=0.032513		
#5. Export price (unit value index)							
a priori sign	+	+	+				
log Px	$\log \frac{W2}{L2\cdot(1-u)}$	$\log \frac{Pmr}{x}$	$\log Px_{t-1}$				
1.	0.084543	0.66583	0.13197	0.45068	0.7181	6.03	1.509
s	(0.035139)	(0.16691)	(0.18136)	(0.50292)		3 & 17	
t	(2.405)	(3.989)	(0.727)	(0.896)	S=0.025891		
2.	0.078241	0.65804		0.73025	0.7075	9.02	1.237
s	(0.033607)	(0.16438)		(0.32025)		2 & 18	
t	(2.328)	(4.003)		(2.280)	S=0.025550		
3.	-0.028899			2.0111	0.2368	1.12	1.654
s	(0.027201)			(0.018730)		1 & 19	
t	(-1.062)			(107.372)	S=0.034192		

#6. Wage rate in non-primary sector

a priori sign + +

$\log \frac{W2}{L2\cdot(1-u)}$ $\log \frac{Q2}{H\cdot L2*}$ $\log[\frac{W2}{L2\cdot(1-u)}]_{t-1}$

Table 3-2 (continued)

		b_1	b_2	b_3	intercept	R	F	D.W.
1.		1.1428			5.0948	0.9954	2071.34	0.894
	s	(0.025110)			(0.12596)		1 & 19	
	t	(45.512)			(40.446)	S=0.027493		
2.		0.49892	0.57015		2.2571	0.9994	8498.51	1.118
	s	(0.055778)	(0.048773)		(0.24673)		2 & 18	
	t	(8.944)	(11.690)		(9.147)	S=0.0096365		

#7. Service price index

a priori sign		+	+					
	log Ps	$\log \frac{W2}{L2\cdot(1-u)}$	log Ps_{t-1}					
1.		0.19774	0.57287		0.94824	0.9988	3911.99	0.962
	s	(0.022538)	(0.042454)		(0.092923)		2 & 18	
	t	(8.773)	(13.493)		(10.204)	S=0.0070778		
2.		0.49223			2.2010	0.9871	725.67	0.312
	s	(0.018272)			(0.012582)		1 & 19	
	t	(26.938)			(174.938)	S=0.022968		

Table 3-2 (continued)

		b_1	b_2	b_3	intercept	R	F	D.W.
#8. Land price index								
a priori sign		+	+					
	log Pa	$\log(I2+Ih+Is)_{t-1}$	log a					
1.		1.2648			-3.0141	0.9743	356.75	0.351
	s	(0.066960)			(0.24051)		1 & 19	
	t	(18.888)			(-12.531)	S=0.13119		
2.			9.5164		10.004	0.8887	71.42	0.148
	s		(1.1260)		(1.0084)		1 & 19	
	t		(8.451)		(9.920)	S=0.26744		

policy has been followed in recent years, even in the face of over-production of rice and balance of payment surplus.[18] Income compensation is conducted through government monopoly of the purchase of rice and other cereals, at prices set at government's discretion. This also makes possible fine tuning in controlling the flow of primary labor force to be transformed into non-primary labor force.[19]

Non-primary products price is determined by two main cost components, namely wage rate and raw material price. Considering the fact that a large percentage of raw material is imported in the case of Japan (see footnote 61 in Chapter 1), the raw material import price is used after being defiated by the exchange rate as the raw material price. As wage rate, compensation of employees is divided by the number of non-primary laborers that are employed.[20]

Japanese exports consist mainly of non-primary goods; therefore, the same specification is used for export price function as for the non-primary products price. This will facilitate a comparison of the two. These two functions will allow us to see the effect of changes in raw material import price and/or changes in exchange rate on non-primary and export prices, as well as the effect of changing wage rate. The result reveals that export price is more sensitive than non-primary products price to changes in raw material import price. Namely, the elasticity with respect to raw material import price is estimated to be 0.507 for for non-primary products price and 0.666 for export price.

The effect of the rising wage level to the service price is straightforward. Only a limited productivity increase is available from additional inputs of capital in this branch of the economy; hence, the service price in many cases directly reflects the wage level itself.

The service price tends to rise with the rise of general wage rate in a competitive labor market.

The fifth price equation explains the movement of urban land price as a function of annual flow of investment which in turn reflects the demand for land in that year. A one year lag is taken for investment to facilitate the solution of the system of equations. Therefore, the function is the flow of investment in previous periods which explains the current land price. An alternative functional form was tested and forms the rate of land utilization (i.e. the ratio of land used for non-primary industry, housing capital, and social capital to total habitable land) which explains the urban land price. It was found, however, that the flow of investment explains land price better.

In the price equations, non-primary wage rate plays an important role in determining the behavior of prices, except the urban land price which is explained by the amount of investment. It is interesting to see different effect of wage level in non-primary sector to prices. The wage rate elasticity of prices are as follows:

primary products price	0.164
non-primary products price	0.092
export price	0.085
service price	0.198

As one may expect, service price is the most sensitive to the changes in wage rate in non-primary sector. Primary products price is also highly sensitive to the non-primary wage rate, supporting the presumption of government income compensation policy. Thus it is seen that, although rice price and some other agricultural prices are under government control and, therefore, considered to be exogenous to the system seemingly being

determined by arbitrary political process, primary products price can be explained endogenously given the policy of keeping the farmers on the farm. This clearly indicates that Japanese agricultural prices will become higher as the economy grows and as the productivity in non-primary sector advances. Thus, as far as primary products price and service price are concerned, the price level has a built-in factor to be pushed upward as the economy grows. The result also indicates that the export price is less sensitive than the non-primary products price to the changes in non-primary wage rate. It has been pointed out that the export price is more sensitive to the raw material import price, which has experienced a downward trend since the early 1950's. This fact, together with the lower elasticity of the wage rate explains the relative decline of the Japanese export price during most of the period under consideration.

In the present model, the wholesale price index consists of primary and non-primary products prices; and the consumer price index consists of primary products prices, non-primary products prices, service prices, and land prices. The difference in components and the relative weights attached to each component explains the coexistence of a rise in consumer price index and the relative stability of wholesale price index.[21] The weights are of 1965 and have the following values.

	wholesale price	consumer price
primary products price	0.113	0.185
non-primary products price	0.887	0.495
service price	--	0.295
land price	--	0.026

Rapidly increasing service and land prices do not affect wholesale price; primary products price which has also been rising rapidly has larger weight in the consumer price index. The rise of service prices caused by the equalization of the wage rate is inevitable where the labor market is competitive. The rise of the primary products price is also due to the equalization process; this, however, is a result of deliberate policy of seeking self-sufficiency of food. The economic rationality of this policy might be questioned in the face of chronic balance of payments surplus and exorbitantly high agricultural prices in comparison to international prices.

3.3.3 GNP-GNE

Equations #11 through #19 are related to gross national product and gross national expenditure. See Figure 3-3 and Table 3-3.

Value added in the primary sector and the non-primary sector are obtained as functions of price level and production quantity of respective sectors. Both are in index form so that they may be aggregated to obtain the gross national product index by simply adding them after they are multiplied with respective weights in the base year. This is then converted to value terms using the base year value. From this value military expenditure and research and development expenditure are subtracted to obtain the portion of gross national product, the disposition of which is at the discretion of the society. If untied foreign aid is to increase in the future, it should also be subtracted because from the viewpoint of the national economy, it is considered a leak. A parallel treatment of military expenditure and research and development expenditure may be questioned by some because the latter apparently will affect the stock of technological knowledge and will have positive effect on the

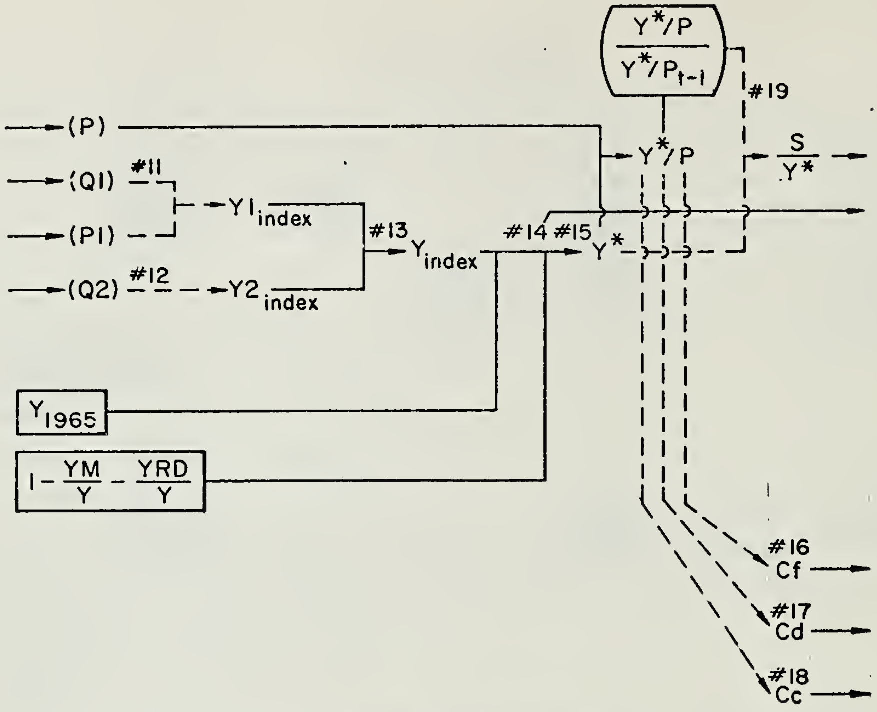

Figure 3-3. Flow Diagram of GNP-GNE Equations

Table 3-3

Value Added, Consumption Functions, and Saving Function

		b_1	b_2	b_3	intercept	R	F	D.W.
#11.	Value added in primary sector, index							
	a priori sign	±	±	+				
	log Y1	log Q1	log P1	log P1·Q1				
1.		1.3549	1.1957		-5.1113	0.9947	852.06	0.859
	s	(0.12619)	(0.11447)		(0.12214)		2 & 18	
	t	(10.737)	(10.446)		(-25.473)	S=0.022763		
2.		2.4995			-5.0062	0.9623	238.39	0.730
	s	(0.16188)			(0.31485)		1 & 19	
	t	(15.440)			(-9.548)	S=0.0588880		
3.				1.2712	-5.0956	0.9946	1752.70	0.874
	s			(0.030364)	(0.11826)		1 & 19	
	t			(41.865)	(-26.176)	S=0.022443		
#12.	Value added in non-primary sector, index							
	a priori sign	+	+	+				
	log Y2	log Q2	log P2	log P2·Q2				
1.		1.1087			-2.23884	0.9985	6379.62	0.586
	s	(0.013881)			(0.024692)		1 & 19	
	t	(79.872)			(-9.672)	S=0.022005		

Table 3-3 (continued)

		b_1	b_2	b_3	intercept	R	F	D.W.
2.		1.1100	-0.030339		-2.18026	0.9985	3027.95	0.579
	s	(0.015719)	(0.16034)		(0.31063)		2 & 18	
	t	(70.617)	(-0.189)		(-0.580)	S=0.022586		
3.				1.0567	-4.2649	0.9946	1775.75	1.078
	s			(0.025077)	(0.094423)		1 & 19	
	t			(42.139)	(-23.986)		S=0.041549	
#16.	Consumption of food							
	a priori sign	+						
	log Cf	$\log \frac{Y^*}{P}$						
		0.30048			2.3116	0.9830	546.10	1.484
	s	(0.012858)			(0.028890)		1 & 19	
	t	(23.368)			(80.012)	S=0.019388		
#17.	Consumption of durable consumer goods							
	a priori sign	+						
	log Cd							
		1.7877			(-0.99160)	0.9801	463.76	0.232
	s	(0.083015)			(0.18652)		1 & 19	
	t	(21.535)			(-5.316)	S=0.12518		

Table 3-3 (continued)

		b_1	b_2	b_3	intercept	R	F	D.W.
#18.	Consumption of non-durable consumer goods							
	a priori sign	+						
	log Cc	$\log \frac{Y^*}{P}$						
		0.74620			1.9198	0.9774	406.57	0.396
	s	(0.037007)			(0.083150)		1 & 19	
	t	(20.163)			(23.088)	S=0.055805		
#19.	Saving function							
	a priori sign	+	+					
	log S/Y*	log Y*/P	$\log \frac{(Y^*/P)}{(Y^*/P)_{t-1}}$					
1.		0.24221	0.12473		-1.0956	0.9427	71.92	0.678
	s	(0.025283)	(0.036791)		(0.056718)		2 & 18	
	t	(9.579)	(3.390)		(-19.316)	S=0.035691		
2.		0.27232			-1.1624	0.9043	85.26	0.652
	s	(0.029491)			(0.066262)		1 & 19	
	t	(9.233)			(-17.542)	S=0.044469		

Table 3-3 (continued)

	b_1	b_2	b_3	intercept	R	F	D.W.
log S	log Y*						
3.	1.1166			-1.1038	0.8341	45.74	0.758
s	(0.16508)			(0.70059)		1 & 20	
t	(6.763)			(-1.575)	S=0.27293		
	+	-					
S including changes in inventories							
log S/Y*	log Y*/P	$\log \frac{(Y^*/P)_t}{(Y^*/P)_{t-1}}$					
4.	0.17841	-0.35672		-0.87002	0.7577	12.13	0.778
s	(0.041673)	(0.62750)		(0.079285)		2 & 18	
t	(4.281)	(-0.568)		(-10.973)	S=0.050653		

growth of the economy. In fact, it is conceivable that there exists some functional relationship between the amount of research and development expenditure and the progress of technological knowledge. It could then be embodied in new investment, making macro-economic technological progress possible. Knowledge in this field is still quite limited, so this relation is not considered explicitly in the present model. Under the assumption of deficient supply capacity limiting the growth, therefore, the three items mentioned here constitute leaks of resources otherwise available for consumption or investment. Gross national product net of military expenditure and research and development expenditure is then deflated by wholesale price level to obtain real disposable GNP. This is either saved or consumed.

According to the estimation, value added in the primary sector is explained by an increase in both the quantity produced and the price, by comparison, value added in the non-primary sector is explained soley by quantity produced. The price term takes a wrong sign and the coefficient is insignificant (see equation #11-2). This is the result of steadily rising primary products price, a reflection of agricultural income compensation policy, and the relative stability of non-primary products price.

Consumption functions are estimated for each sector, consistent with the two sector classification of production functions in this study. Further, in order to see the effect of accumulated stock of consumer durable goods, non-primary goods consumption is classified into consumption of nondurable goods and durable goods. The three consumption functions may reflect changing consumer demand pattern as income level

becomes higher. The elasticity of consumption with respect to real disposable GNP (i.e. military and R&D expenditure subtracted) are

primary goods	0.300
non-durable consumer goods	0.746
durable consumer goods	1.788

Income elasticity of consumption is markedly high for durable consumer goods, followed by non-durable consumer goods, with that of primary goods being the lowest.[22] Apparently this underlies the rapid decline in the Engel coefficient in post-war Japan[23] and an extremely rapid spread of all kinds of durable consumer goods.[24] It is also noted that large and rapidly growing stock of durable consumer goods implies increasing need for housing and social capital which are supplementary to the use of durable goods. Increased need for highways, sewerage systems, recreational facilities, and better housing are some examples.

The saving function is defined in terms of the GNP net of military and research and development expenditures, in contrast to the usual convention of defining in terms of total GNP.[25] The effect of the growth rate on saving rate is estimated by the inclusion of growth term as has been discussed in Section 2.3.1. The coefficient on growth term is measured to be significant. This can be interpreted that as long as economic growth rate is kept high, the source of capital formation is automatically forthcoming. It also indicates that capital formation proportion will not be a bottleneck in a continued rapid growth process.

3.3.4 Capital Formation

Capital formation equations includes #20 through #30. See Figure 3-4 and Table 3-4.

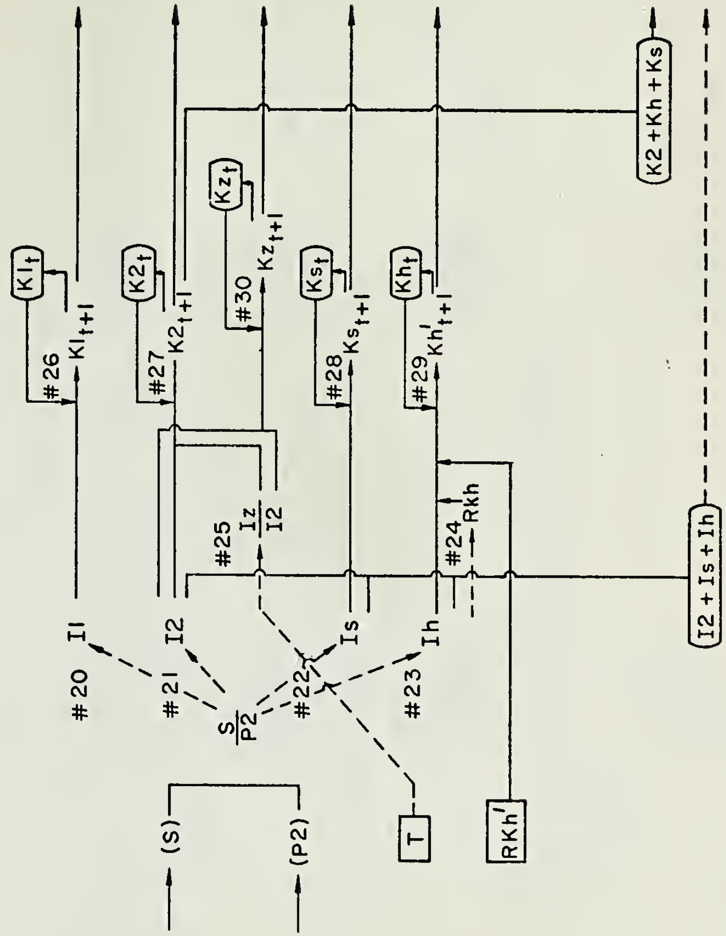

Figure 3-4. Flow Diagram of Capital Formation Equations

Table 3-4

Capital Formation

	b_1	b_2	b_3	intercept	R	F	D.W.
#20. Primary sector capital formation							
a priori sign	+						
log I1	log $\frac{S}{P2}$						
	0.78537			1.0775	0.9657	263.01	0.824
s	(0.048426)			(0.082819)		1 & 19	
t	(16.217)			(13.010)	S=0.096125		
#21. Non-primary sector capital formation							
	1.0257			1.7465	0.9979	4617.60	0.464
s	(0.015094)			(0.025814)		1 & 19	
t	(67.953)			(67.656)	S=0.029962		
#22. Social capital formation							
log Is							
	0.83987			1.4803	0.9885	815.75	0.844
s	(0.029406)			(0.050290)		1 & 19	
t	(28.561)			(29.435)	S=0.058370		

Table 3-4 (continued)

	b_1	b_2	b_3	intercept	R	F	D.W.
#23. Housing capital formation							
log Ih							
	1.1695			0.91351	0.9922	1208.40	1.073
s	(0.033642)			(0.057535)		1 & 19	
t	(34.762)			(15.877)	S=0.066778		
#24. Housing capital removal							
log Rkh	log Ih						
	1.1194			-1.3905	0.9978	4461.87	0.659
s	(0.016758)			(0.048492)		1 & 19	
t	(66.797)			(-28.675)	S=0.039205		
#25. Share of pollution prevention investment (1965-1972)							
a priori sign	+						
log Iz/I2	T						
	0.086048			-3.2693	0.9446	49.76	1.381
s	(0.012198)			(0.23949)		1 & 6	
t	(7.054)			(-13.650)	S=0.079050		

The total amount of savings (changes in inventories excluded) is deflated by a non-primary products price index to obtain real savings, which is invested in productive purposes in primary or non-primary sector or in social overhead as social capital investment or housing capital investment. The allocation of investment as reflected in the relative share of these four components will have a direct implication on the growth rate of the economy as well as on the pattern of the growth and the welfare level of members of the society.

The elasticity of investment for each item with respect to the available resources for capital formation are as follows:

primary sector	0.785
non-primary sector	1.026
social capital	0.840
housing capital	1.170

The results clearly indicate that the amount of social capital has been declining relative to the productive capital of non-primary sector during the sample period. Ruling out initial excessive supply of social capital, this could mean either (1) the Japanese economy failed to provide necessary social capital stock, or (2) the Japanese managed to save on the social capital requirement by more efficient use of the existing stock and/or increased concentration of production and population to, say, what is called the Tokaido megalopolis. It should be remembered at the same time that the large proportion of social capital provided is supplementary to capital stock for production purposes. On the other hand, as can be judged from the changing consumption pattern and especially from rapidly increasing durable consumer goods, the demand for social capital for final use will certainly increase.. Progress of urbanization also

implies increased need for social capital such as parks and sewerage. According to estimates, housing capital formation has increased its share in total capital formation. Massive destruction by World War II and very rapid urbanization coupled with a population increase contributed to the urgency of housing capital formation. However, the housing problem both in terms of quantity and quality has not been eliminated despite an effort to do so. If housing capital formation continues to be maintained at a high level, increased social capital formation will have to be met by decreasing the share for productive purposes.

Another source that will make the share of productive capital small in relation to available investment funds is the increase in pollution prevention investment. In this model, provision is made to account for the increasing share of pollution prevention investment, which is assumed to be nonproductive and contributes only to the removal of pollutants coming out of production processes. The share of pollution prevention investment in non-primary capital formation is estimated as a function of time. Although ideally this should be explained by the level of pollution or other more plausible variables, empirical knowledge does not permit the establishment of a quantitative relation.

Capital accumulation proceeds as new investment is added to the existing stock of capital. Depreciation is not considered in the model because of the difficulty of estimating economic depreciation as opposed to accounting depreciation, and possible underestimation of the role of capital when depreciation on accounting grounds is adopted. Housing capital stock is an exception, where housing capital removed and damaged are subtracted.[26] Housing capital removal is estimated as a function of new housing construction, which is represented by housing capital

formation. This functional relation is plausible from an empirical point of view because a large proportion of removal is considered to be replacement. The fit is also very good. Non-primary capital stock is defined excluding the pollution prevention capital, and the stock of the latter is obtained separately for its direct implication on the improvement of the level of environmental pollution.

3.3.5 Foreign Trade

The model has one export function and one import function, although it can be extended easily to clarify sectoral classification.[27] See equations #31 through #33, Figure 3-5 and Table 3-5.

Exports are determined as a function of real world income and relative prices of Japanese and world products, and have been adjusted for exchange rate. The growth rate of industrial production in Japan is included to test the hypothesis that Japanese manufacturers may find foreign market more attractive when the domestic market is slackened. This is equivalent to saying that Japanese manufacturers have been using foreign market as a cushion against business cycles.

A negative sign is expected on the cycle variable.[28] This was not found. This is due to the fact that either (1) there is no export drive or (2) the specification of the cycle dummy is not appropriate. Considering that industrial production growth tended to accelerate toward the end of our sample period, accompanied by rapid growth of exports, the cycle variable should probably be specified as the deviation from the average rate of industrial growth over one business cycle, and not over the sample period as a whole. In the pres·nt model the cycle variable is dropped. The relative price term also had a wrong sign, when estimated directly. Extraneous information is used in determining the

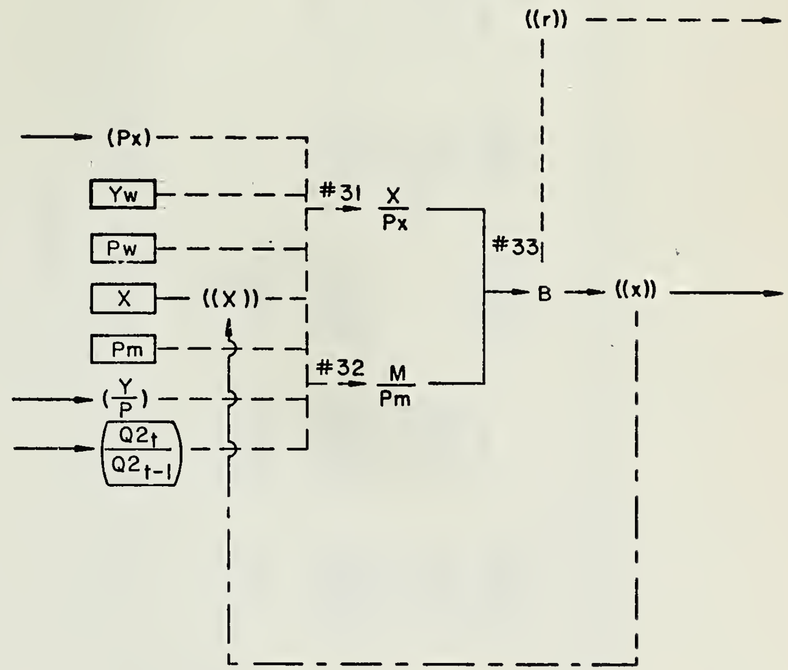

Figure 3-5. Flow Diagram of Foreign Trade Equations

Table 3-5

Foreign Trade

		b_1	b_2	b_3	intercept	R	F	D.W.
#31. Export								
a priori sign		+	-	-				
$\log \frac{X}{Px}$		$\log \frac{Yw}{Pw}$	$\log \frac{x \cdot Px}{Pw}$	$\log \frac{Q2_t}{Q2_{t-1}}$				
1.		3.0114	-0.80*		1.4592	0.9898	917.39	1.818
	s	(0.099425)			(0.015882)		1 & 19	
	t	(30.288)			(91.874)	S=0.056602		
2.		3.0260	-0.80*	0.37308	1.4378	0.9902	454.58	1.738
	s	(0.10121)		(0.41380)	(0.028637)		2 & 18	
	t	(29.897)		(0.901)	(50.206)	S=0.056883		
3.		3.2911	0.86664		1.4306	0.9932	661.57	1.079
	s	(0.13616)	(0.62645)		(0.017506)		2 & 18	
	t	(24.170)	(1.383)		(81.720)	S=0.049268		
4.		3.2974	0.91957	-0.067606	1.4336	0.9932	417.21	1.073
	s	(0.14509)	(0.72042)	(0.41217)	(0.025561)		3 & 17	
	t	(22.726)	(1.276)	(-0.164)	(56.084)	S=0.050656		

*Obtained by extraneous estimation.

Table 3-5 (continued)

		b_1	b_2	b_3	intercept	R	F	D.W.
#32. Import								
a priori sign		+	-	+				
$\log \frac{M}{Pm}$		$\log \frac{Y}{P}$	$\log \frac{Pm}{x \cdot P}$	$\log \frac{Q2_t}{Q2_{t-1}}$				
1.		0.84657	-1.4009	0.68764	-0.67264	0.9938	454.15	1.653
	s	(0.052618)	(0.29961)	(0.33057)	(0.12219)		3 & 17	
	t	(16.089)	(-4.675)	(2.080)	(-5.504)	S=0.043423		
2.		0.86724	-1.2091		-0.68170	0.9922	573.13	2.118
	s	(0.056245)	(0.31031)		(0.13292)		2 & 18	
	t	(15.419)	(-3.896)		(-5.128)	S=0.047266		
3.		0.94647	-0.72*	0.45653	-0.89966	0.9898	438.27	1.361
	s	(0.032089)		(0.34903)	(0.078084)		2 & 18	
	t	(29.495)		(1.308)	(-11.521)	S=0.048185		

*Obtained by extraneous estimation.

coefficient on the relative price term and in adopting the value estimated by Houthakker and Magee.[29]

The import function is symmetrically specified in terms of Japan's real GNP, relative prices, and cycle variables defined as the growth rate of industrial production. All the coefficients have correct signs and plausible values. They are all significant, including the cycle variable. This indicates that, unlike exports, imports are sensitive to the level of domestic economic activity, reflecting the dominance of business-cycle-sensitive commodities in Japanese import structure.[30]

Since the functions in this study are log-linear, the coefficients represent elasticities with respect to income, price, and cycle. It is of interest to compare the results obtained here with those which Houthakker et al. have obtained in their recent work. They used double-logarithmic equations in an attempt to measure income and price elasticities for various countries for the period 1951-1966. Their result for Japan is summarized below, along with Kinoshita's and Takahashi's.[31]

	Export		Import	
elasticities	income	price	income	price
Houthakker et al. (1951-66)	3.55	(-)0.80	1.23	(-)0.72
Kinoshita (1920-64)	2.0124	(-)1.0176	0.8889	(-)1.0866
Takahashi (postwar)	2.386	(-)1.962	0.961	(-)0.855

While the price elasticity of import in the present model is nearly twice as large as Houthakker and Magee's and is estimated to be (-)1.400, the income elasticities are comparable to theirs which are 3.011 for

export and 0.847 for import. Apparently Japanese export elasticity is estimated to be more than three times the import elasticity, implying, as Houthakker writes, that even if Japan's income grows three times as fast as the income of the rest of the world Japan's exports will not get out of line with its exports (relative prices and exchange rates remaining constant). The estimated income elasticity of imports of less than one is in line with the fact that Japan's imports have been declining relative to the GNP over the sample period.

Balance of trade is expressed as the ratio of exports to imports. Both are adjusted for price changes and alteration of exchange rate. When the trade is in balance, the ratio will be one. Under a fixed exchange rate, this definition will express the amount of surplus or deficit as the ratio to the level of imports. Alternatively, this definition can be used to determine the equilibrium exchange rate which will eliminate surplus or deficit and maintain the ratio of exports to imports at unity. In this case it is possible to trace the changing level of the exchange rate as the economy grows.[32]

In the current model, there is no feedback of balance of trade to the rest of the economy. Implicitly, however, balance of trade is one of the indicators that the policy authority would watch in determining the level of domestic economic activity. It is implicitly assumed that the rate of capacity utilization in the non-primary sector is determined by the policy authority to keep the balance of trade within reasonable limits.[33]

3.3.6 Population Status Indicators

The rather large number of equations found in this section reflects the character of the model, a long-term development model, which aims at analyzing the welfare implication of economic development. See equations #34 through #51 in Figure 3-6 and Table 3-6. In the present study, population is not simply a factor of production; it is the final objective of the economic activity to which the benefit of economic activity should finally belong. Every economic system assumes, explicitly or implicitly, that this would be so.

The main driving force that affects the population-related variables in this model is the level of material benefit per capita, which will be discussed separately below. The material benefit indicator is theoretically superior to, for example, per capita income because the former reflects the benefit of stocks such as housing and social capital and the stock of durable consumer goods as well as annual flow of consumed goods.

The population size of the next period is determined by birth rate, death rate, and rate of immigration in the current period. Of these variables, birth rate and death rate are endogenous in the model.

Japan's birth rate showed a rapid decline since World War II unprecedented in world demographic history. The decline, however, came to a halt in the late fifties, and the trend has turned slightly upward since.[34] A dummy variable is used to take care of this shift in trend; the dummy takes zero for 1950-1957 and unity for 1958-1970. Another characteristic in the birth rate is the sudden and sharp drop recorded in 1966, which is attributed to the superstition of "Hinoe-uma."[35] Another dummy is introduced for the year of Hinoe-uma which takes unity for 1966 and zero otherwise. The years preceding and following 1966 are

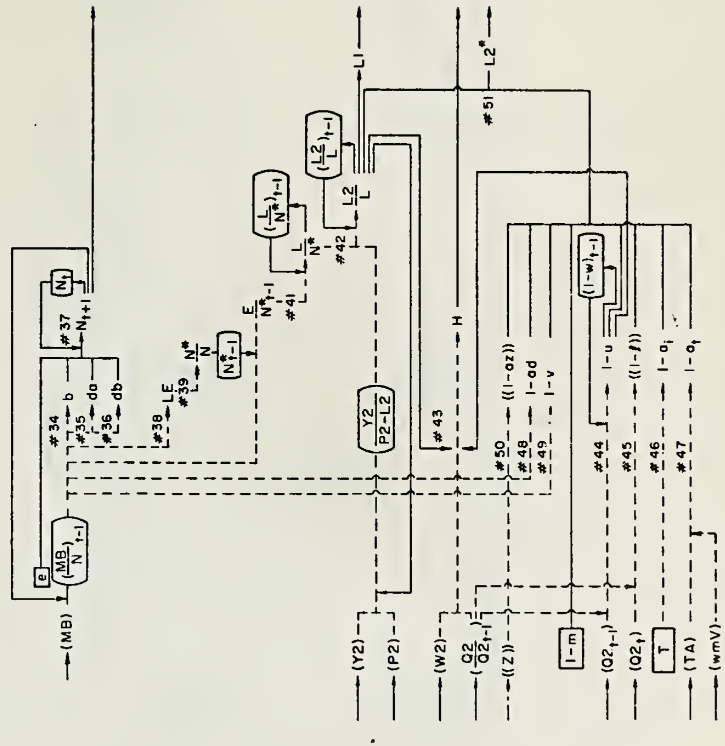

Figure 3-6. Flow Diagram of Population Status Indicators Equations

Table 3-6

Birth Rate and Death Rates

		b_1	b_2	b_3	b_4	intercept	R	F	D.W.
#34. Birth rate									
	a priori sign	-	+	+	-				
	log b	$\log(\frac{MB}{N})_{t-1}$	D1	$D1 \cdot \log(\frac{MB}{N})_{t-1}$	D2				
1.		-0.88358	1.2128	0.98550	-0.12201	-2.8543	0.9871	152.88	1.555
	s	(0.055756)	(0.079911)	(0.061810)	(0.012569)	(0.074887)		4 & 16	
	t	(-15.847)	(15.177)	(15.944)	(-9.707)	(-38.114)	S=0.011937		
2.		-0.88358	1.1631	0.94641		-2.8543	0.9079	26.59	2.653
	s	(0.14198)	(0.20307)	(0.15706)		(0.19070)		3 & 17	
	t	(-6.223)	(5.727)	(6.025)		(-14.967)	S=0.030398		
3.		-0.22121				-1.9773	0.6295	12.47	0.873
	s	(0.062642)				(0.072946)		1 & 19	
	t	(-3.531)				(-27.106)	S=0.053306		
#35. Death rate (other than infants)									
	a priori sign	-	+	+					
	log da	$\log(\frac{MB}{N})_{t-1}$	D1	$D1 \cdot \log(\frac{MB}{N})_{t-1}$					
1.		-0.41160	0.40562	0.33225	-2.6614		0.9441	46.52	1.612
	s	(0.068052)	(0.097333)	(0.075280)	(0.091402)			3 & 17	
	t	(-6.048)	(4.167)	(4.413)	(-29.117)		S=0.014570		

Table 3-6 (continued)

		b_1	b_2	b_3	b_4	intercept	R	F	D.W.
2.		-0.18479			-2.3618		0.8625	55.20	0.817
	s	(0.024871)			(0.028962)			1 & 19	
	t	(-7.430)			(-81.549)		S=0.021164		
#36. Infant death rate									
	a priori sign	-							
	log db	$\log(\frac{MB}{N})_{t-1}$							
		-1.0908			-2.7929		0.9951	1948.45	1.885
	s	(0.024711)			(0.028776)			1 & 19	
	t	(-44.141)			(-97.054)		S=0.021028		

likely to be affected by the effort to avoid child births in 1966, but no attempt was made to remove the effect in the birth rate function presented in this model. The magnitude of the decline is remarkable, amounting to 26 percent, and reveals the technical skill in applying contraceptive measures.

One peculiarity of the present model is that death rate is estimated separately for infants and for those other than infants. This is better than to treat them singly because infant death rate is more sensitive to economic growth and shows a very rapid decline, whereas death rate for those other than infants more or less stays at the same level. In view of the marked decline in death for other than infants in earlier half of our sample period, a dummy variable was tested (zero for 1950-1957 and unity for 1958-1970), which proved significant. No dummy was used in determining the death rate for infants since it has experienced a continued declining trend. According to the results obtained, material benefit elasticity of the death rate is only (-)0.079 for the recent period compared to (-)1.091 for infants death rate.

Material benefit levels also determine life expectancy. The life expectancy was 51.54 years for males and 55.28 years for females in 1947, 57.91 years and 61.13 years in 1950, and 70.2 years and 75.6 years in 1971. This improvement clearly owes not only to improved current consumption but also to improved social facilities and other stocks, justifying our use of material benefit as the regressor.[36] A logarithmic, reciprocal transformation is used because life expectancy will have an asymptotic level, rather than increasing infinitely. In general, this function has the form $\log Y = \alpha - \beta X$. As $X \rightarrow \infty$, $Y \rightarrow e^{\alpha}$. Therefore, in the case of this model, as material benefit increased infinitely, life

expectancy will approach e^{α}, where α is estimated as the intercept. The result (average of male and female) shows the intercept (in log) of 1.8818, which is approximately 76.17 years. The curve passes through the origin since

$$\frac{dY}{dX} = e^{\alpha-\beta/X} \left(\frac{\beta}{X^2}\right) ,$$

which is another advantage of using this functional form because life expectancy is expected to go to zero when material benefit approaches zero.

Next, the ratio of working age population to total is considered. As the structure of population changes reflecting longer life expectancy, and the share of dependent youths becomes smaller relative to total population, the share of working age population is expected to increase. This is potentially a favorable factor to economic growth, but we cannot say anything definite until the labor force participation ratio is known. In the present model, the ratio of working age population to the total is estimated as a function of life expectancy.

Labor force participation is affected by various factors, including age and sex structure of the labor force, expected income, and urbanization. One of the dominant factors is school attendance,[37] which is expected to rise as the economy develops both by the desire of the people to acquire education for its own sake and by the demand of producing sectors which require a technically-trained labor force rather than a manually-experienced one. First, school attendance among working age population is estimated as a function of per capital material benefit (c.f. equation #40). For 1966-1970, school attendance declined as the share of working age population due to changes in age structure:

school age population has declined relatively due to earlier accerleration and subsequent decline in birth rate. A longer life expectancy also contributed to it. A dummy variable is introduced for the period since 1966.

Then labor force participation is estimated as a function of school attendance among working age population (equation #41). After an initial increase, a decline of labor force participation is observed through 1955 to 1970. This is attributed to the decline in the female labor force participation due to a shift of labor force out of primary sector where female labor force participation has been high to the non-primary sector where it is lower. More detailed analysis of this point has to be relegated to a population model. Here, the periods before and after 1955 are simply distinguished by a dummy variable.[38]

The allocation of labor force between two sectors is determined by the level of value added per worker in the non-primary sector because this is considered to be the sector which is pulling the system.[39] (See equation #42.) Value added in the non-primary sector is expected to reflect the income inducement as well as other mechanisms of attracting labor force out of the primary labor force. The non-primary labor force factor in deriving value added per worker is not adjusted for unemployment. It should be noted that labor force allocation does not guarantee actual employment in the non-primary sector of our model; the present model indicates the existence of unemployment only in the non-primary sector. It is assumed that this does not deter movement of workers between the two sectors because they make their decisions based on expected earnings, considering both the amount of income and the probability of being actually employed. This is in line with recent literature.[40]

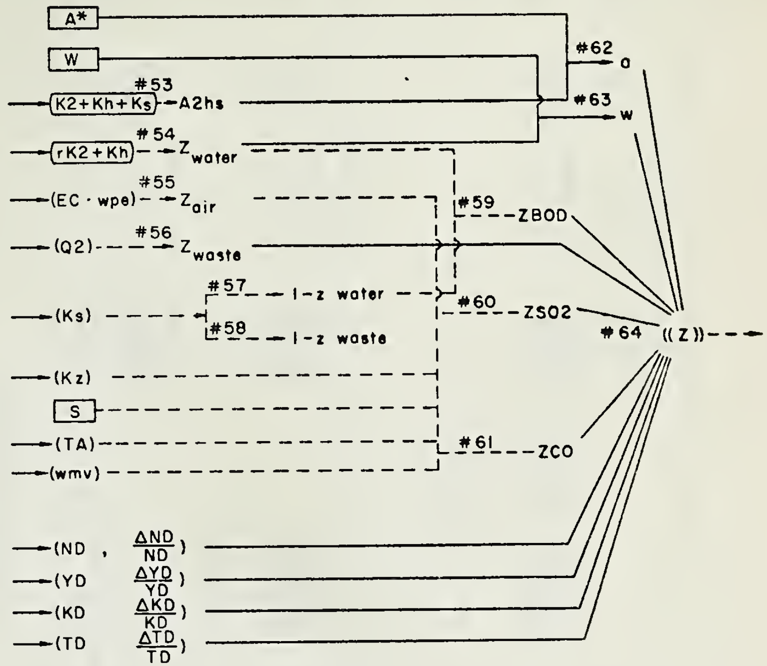

Figure 3-7. Flow Diagram of Environmental Indicators Equations

Table 3-7

Population Status Indicators

		b_1	b_2	b_3	b_4	intercept	R	F	D.W.
#38. Life expectancy									
a priori sign		+							
log LE		$\frac{1}{(MB/N)_{t-1}}$							
		-0.0033596				1.8818	0.9870	718.99	1.793
	s	(0.00012529)				(0.0020921)		1 & 19	
	t	(-26.814)				(899.493)	S=0.0036737		
#39. Ratio of working age population									
a priori sign		+							
log N*/N		log LE							
		0.94912				-1.8897	0.9111	92.82	0.443
	s	(0.098511)				(0.18029)		1 & 19	
	t	(9.634)				(-10.481)	S=0.0098479		
#40. School attendance among working age population									
a priori sign		-							
$\log \frac{E}{N^*_{t-1}}$		$\frac{1}{(\frac{MB}{N})_{t-1}}$							

Table 3-7 (continued)

		b_1	b_2	b_3	b_4	intercept	R	F	D.W.
1.		-0.012945				-0.89179	0.9648	255.84	0.545
	s	(0.00080933)				(0.013514)		1 & 19	
	t	(-15.995)				(-65.990)	S=0.023731		
		$\log(\frac{MB}{N})_{t-1}$	D6	$D6 \cdot \log(\frac{MB}{N})_{t-1}$					
2.		0.58650	-0.97898	-1.0013		-0.40974	0.9801	138.72	0.810
	s	(0.035276)	(0.16520)	(0.18081)		(0.043599)		3 & 17	
	t	(16.625)	(-5.925)	(-5.537)		(-9.397)	S=0.019144		
#41. Labor force participation rate									
a priori sign		+	+	-	-				
$\log \frac{L}{N^*}$		$\log(\frac{E}{N^*_{t-1}})$	$\log(\frac{L}{N^*_{t-1}})$	D5	$D5 \cdot \log(\frac{E}{N^*_{t-1}})$				
1.		0.18847	0.43277	-0.35872	-0.31228	0.13148	0.9425	31.84	2.362
	s	(0.049094)	(0.16967)	(0.081141)	(0.071837)	(0.056382)		4 & 16	
	t	(3.839)	(2.550)	(-4.420)	(-4.347)	(2.331)	S=0.0050380		
2.		-0.020256	0.85045			-0.047786	0.8636	26.42	1.536
	s	(0.018448)	(0.12285)			(0.031216)		2 & 18	
	t	(-1.098)	(6.922)			(-1.530)	S=0.0071667		

Table 3-7 (continued)

		b$_1$	b$_2$	b$_3$	b$_4$	intercept	R	F	D.W.
#42. Labor force allocation									
a priori sign		+	+						
$\log(\frac{L2}{L})_{t+1}$		$\log(\frac{Y2}{L2})_t$	$\log(\frac{L2}{L})_t$						
		0.015748	0.85403			0.061973	0.9956	1037.56	3.085
	s	(0.014325)	(0.057678)			(0.059906)		2 & 18	
	t	(1.099)	(14.806)			(1.034)	S=0.0062905		
#43. Monthly work hours in non-primary sector									
a priori sign		+	+	-	-				
log H		$\log \frac{W2}{L2\cdot(1-u)}$	$\log \frac{Q2_t}{Q2_{t-1}}$	D4	$D4\cdot\log \frac{W2}{L2\cdot(1-u)}$				
		0.084096	0.059567	-0.096026	-0.13791	2.3601	0.9865	145.37	1.613
	s	(0.0046224)	(0.012513)	(0.0042627)	(0.0058606)	(0.0039343)		4 & 16	
	t	(18.192)	(4.760)	(-22.526)	(-23.532)	(599.865)	S=0.0016796		
#44. Employment ratio									
a priori sign		+	+	+					
log (1-u)		$\log \frac{Q2_{t-1}}{Q2_{t-2}}$	$\log Q2_{t-1}$	$\log(1-u)_{t-1}$					

Table 3-7 (continued)

		b$_1$	b$_2$	b$_3$	b$_4$	intercept	R	F	D.W.
1.		0.028140	0.0064721	0.36804		-0.018989	0.8868	20.87	2.160
	s	(0.014002)	(0.0018936)	(0.17047)		(0.0045641)		3 & 17	
	t	(2.009)	(3.417)	(2.158)		(-4.160)	S=0.0020641		
2.		0.021326	0.0094738			-0.027482	0.8532	24.08	1.190
	s	(0.014964)	(0.0014103)			(0.0025387)		2 & 18	
	t	(1.425)	(6.717)			(-10.825)	S=0.0022643		
3.			0.0095691			-0.026399	0.8350	43.76	1.190
	s		(0.0014464)			(0.0024872)		1 & 19	
	t		(6.615)			(-10.614)	S=0.0023249		
#46. Labor force net of absence due to industrial accidents									
a priori sign		+	+						
log(1-ai)		T	$\log(\frac{Y}{P\cdot N})_{t-1}$						
1.		0.000044953				-0.0011671	0.9895	897.83	0.922
	s	(0.0000015002)				(0.000018838)		1 & 19	
	t	(29.963)				(-61.953)	S=0.000041630		
2.			0.00020194			-0.00019330	0.7409	23.12	0.509
	s		(0.00004199)			(0.00010830)		1 & 19	
	t		(4.808)			(-1.784)	S=0.00019422		

Table 3-7 (continued)

	b_1	b_2	b_3	b_4	intercept	R	F	D.W.
#47. Labor force net of absence due to traffic accidents								
a priori sign -								
	log(1-at) log TA·wmv							
	-0.000076447				0.00031079	0.9688	290.31	0.365
s	(0.0000044866)				(0.000022579)		1 & 19	
t	(-17.038)				(13.764)	S=0.0000099933		
#48. Labor force net of absence due to infectious diseases								
a priori sign +								
	log(1-ad) $\log(\frac{MB}{N})_{t-1}$							
	0.0010566				0.00072038	0.9437	154.84	2.148
s	(0.000084910)				(0.000098877)		1 & 19	
t	(12.443)				(7.285)	S=0.000072255		

Table 3-7 (continued)

	b_1	b_2	b_3	b_4	intercept	R	F	D.W.
#49. Labor force net of absence due to imprisonment								
a priori sign -								
	log(1-v) $\log(\frac{MB}{N})_{t-1}$							
	0.00071070				-0.00033773	0.9789	437.57	1.110
s	(0.000033975)				(0.000039564)		1 & 19	
t	(20.918)				(8.536)	S=0.000028911		

Hours worked, which represent the ulitization rate of labor force, is a function of wage rate and the phase of the business cycle. It should be expected that the hours worked will diminish as the economy grows and as people begin to prefer leisure over additional income. In Japan this process seems to have been taking place since around 1961. The extension of work hours in the preceding period probably reflect increased employment opportunity as the Japanese economy began to recover from the war and return to normalcy. In other words, workers were working shorter hours than they wanted to by sharing limited employment opportunities. After full employment had been achieved around 1961, a secular downward trend in work hours is observed. A dummy variable is used to distinguish the two periods; the first half is the period from 1950 to 1960 and the second half from 1961 to the present. The general trend is subject to fluctuation caused by the business cycle phase, which is measured here as the growth rate of non-primary production.

A positive sign on the cycle variable is expected: change in demand for labor is first adjusted by its utilization rate, followed by adjustment of the level of employment.[41]

The existing stock of labor force is not necessarily utilized effectively. The model takes into account unemployment, labor disputes, industrial accidents, traffic accidents, infectious diseases, detention in prison, military service, and diseases caused by environmental pollution. The last of these factors is included in the model only formally and no empirical observation can be made due to the limited availability of time series data. Labor disputes and military personnel are treated as exogenous variables in this model.[42] Industrial disease, though important, is not included in this study due to lack of data.[43]

In the present study, therefore, functions are fitted to explain unemployment, industrial accidents, traffic acidents, infectious diseases, and imprisonment. These are indicators of the well-being of members of the society, while at the same time they exert their influences on the production process through decreased utilization of available labor resources.

The unit of measurement is unified into man-years lost. This is intended (1) to facilitate a comparison of the relative magnitude of these causes of inability to work and (2) to build them into the model as an integral part, with their feedback effect on the production process. Then the ratios of man years not lost due to these causes are calculated. In other words, the model includes employment ratio, labor force not lost due to labor disputes, labor force not suffered from industrial accidents or traffic accidents, and so forth. Since each of the causes are considered independent of each other, this definition allows us to define multiplicatively the non-primary labor force actually engaged in production.

In the model, unemployment in labor statistics is considered to be unemployment in the non-primary sector. Possible unemployment or disguised unemployment in the primary sector is not considered here. The unemployment ratio is undoubtedly affected by cyclical fluctuation. In the case of Japan, it has experienced a declining trend as the economy approaches the state of full employment. The declining trend is plausible when we consider that as the level of production increases, demand for labor will also have a rising trend, contributing to the exhaustion of the pool of the unemployed. Since employment ratio is one minus unemployment ratio, positive signs are expected in both cycle and

trend variables (see equation #44). As the cycle variable the growth rate of industrial production is used, and as the trend variable industrial production. It was found that a one year lag on independent variables explains better than using current values.

As for the labor force not being affected by industrial accidents, the ratio is expected to increase as the economy grows thanks to various safety measures. This function is explained by the time trend[44] (see equation #46).

If today's society looks like a more dangerous place to live, it is because of traffic accidents. In the model, equation #47 explains the labor force net of absence due to traffic accidents by transportation activity and the share of motor vehicles in it. Empirical investigation reveals that the rising human toll of traffic accidents is caused by motor vehicles. The number of railway accidents is virtually at the same level despite rapid increase in transportation by rail, implying that railway traffic is becoming safer per unit of transportation activity. Road traffic is also becoming safer per unit of transportation activity, but the increase in the absolute level of road traffic more than compensates for it, resulting in an increase in the number of victims.[45]

Next, equation #48 considers the cases of infectious diseases. One benefit which economic development brought about is a decrease in the number of cases of infectious diseases which was made possible by improvement of sanitary conditions and the introduction and popular use of new medicines. The share of labor force not suffering from infectious diseases is explained by per capita material benefit.[46]

Finally, equation #49 explains the number of inmates in the society. It may not reflect the crime rate if the detention period has varied

from year to year due to changes in, for example, judicial system. In the absence of this kind of information, we can interpret it as expressing a general trend of criminal conduct. Crime is apparently an important aspect of the society. The number of inmates has experienced a clear downward trend in post-war Japan,[47] contrary to the experience in other countries (if this can be interpreted as corresponding to the drop in the crime rate). The function explains labor force net of absence due to imprisonment by per capita material benefit.

3.3.7 Environmental Indicators

The equations related to environmental indicators include #52 through #64. They consist of input of environment to economic activity, output of pollutant from economic activity, pollutant removal rates, and the actual level of pollution.

First, input of land is explained by non-primary, housing, and social capital stock. It can be reasonably expected that increased capital stock will require more use of land. In equation #53, only the input of land for non-primary production, housing, and social capital is considered;[48] since the use of land for agriculture and forestry apparently has different environmental implications, it is not included here. Sown area is treated as an exogenous variable in our model and included in the production function of the primary sector.

Another major input of environment to economic activity is that of water resources. In this model, input of water is estimated as a function of the total of non-primary capital stock and housing capital stock.[49] Non-primary capital stock is adjusted for the rate of capacity utilization because the demand for water for industrial production is expected to reflect business cycles.

Table 3-8

Environmental Indicators

	b_1	b_2	b_3	intercept	R	F	D.W.
#53. Land used (other than primary)							
a priori sign +							
log A2hs	log(K2+Kh+Ks)						
	0.27957			2.6923	0.9950	1899.47	0.932
s	(0.0064147)			(0.030998)		1 & 19	
t	(43.582)			(86.852)	S=0.0054224		
#54. Input of water = Output of polluted water							
a priori sign +							
log(Zwater) (total)	log(r·K2+Kh)						
	1.1796			-1.3475	0.9654	260.53	0.200
s	(0.073080)			(0.34172)		1 & 19	
t	(16.141)			(-3.943)	S=0.064990		
#55. Output of air pollutant (consumption of sulphur-containing resources)							
a priori sign +							
log Zair	log EC·wpc						
	0.81430			1.0366	0.9985	6585.43	1.476
s	(0.010034)			(0.049225)		1 & 19	
t	(81.150)			(21.057)	S=0.014226		

Table 3-8 (continued)

	b_1	b_2	b_3	intercept	R	F	D.W.
#56. Output of waste							
a priori sign +							
log Zwaste	log Q2						
	0.73099			3.2549	0.9985	6628.76	1.006
s	(0.0089783)			(0.015967)		1 & 19	
t	(81.417)			(203.854)	S=0.014249		
#57. Ratio of untreated polluted water (1950-1970)							
a prior sign -							
log(1-zwater)	log Ks						
	-0.15249			0.58141	0.9863	679.97	0.942
s	(0.0058476)			(0.024451)		1 & 19	
t	(-26.076)			(23.778)	S=0.0037332		
#58. Ratio of uncollected waste (1965-1969)							
a priori sign -							
log(1-zwaste)	log Ks						
	-1.2049			4.8171	0.9983	915.92	3.224
s	(0.039812)			(0.17327)		1 & 3	
t	(-30.264)			(27.800)	S=0.0047003		

Table 3-8 (continued)

	b_1	b_2	b_3	intercept	R	F	D.W.
#59. Water pollution level (1960-1969)							
a priori sign	+						
log ZBOD	log Zwater·(1-zwater)						
	1.6543			-6.3693	0.8283	17.49	1.850
s	(0.39550)			(1.6880)		1 & 8	
t	(4.182)			(-3.773)	S=0.12082		
log Ammonium Nitrogen							
	2.7109			-11.134	0.7323	9.25	0.911
s	(0.89105)			(3.8031)		1 & 8	
t	(3.042)			(-2.927)	S=0.27220		
log ABS							
	2.7466			-11.761	0.7930	13.55	1.027
s	(0.74590)			(3.1836)		1 & 8	
t	(3.682)			(-3.694)	S=0.22786		
#60. Air pollution level: S02 (1964-1971)							
a priori sign	+	-					
log ZSO_2	log Zair·Zs	log Kz					
1.	2.3618	-1.0018		-5.1352	0.9173	13.28	1.784
s	(0.49461)	(0.19437)		(1.3196)		2 & 5	
t	(4.774)	(-5.153)		(-3.891)	S=0.039087		

Table 3-8 (continued)

	b_1	b_2	b_3	intercept	R	F	D.W.
2.	-0.0049050			0.68944	0.0047	0.00	0.803
s	(0.42157)			(1.5628)		1 & 6	
t	(-0.011)			(0.441)	S=0.089650		
#61. Air pollution level: CO (1964-1971)							
a priori sign	+	-					
log ZCO	log TA·wmv	D8					
1.	0.46096	-0.29816		-1.8772	0.9854	84.08	2.877
s	(0.048780)	(0.023000)		(0.27001)		2 & 5	
t	(9.449)	(-12.963)		(-6.952)	S=0.018744		
2.	-0.011094			0.70171	0.0259	0.00	1.618
s	(0.17432)			(0.98050)		1 & 6	
t	(-0.063)			(0.715)	S=0.10066		

Environmental implications of input of land and water are not evident from the absolute level. For this reason, the rate of land utilization and the rate of water utilization are defined in relation to available supply in equations #62 and #63. These indicators express the portion of resources used as the ratio of total habitable land and to total precipitation, respectively.

Input of natural resources is considered next. In order to keep the size of the model as small as possible, only the case of petroleum and coal is included here. In equation #55, consumption of these two resources combined is estimated as a function of energy consumption adjusted for the share of coal and petroleum in total energy supply.

Then, output of pollutant and resultant environmental pollution is analyzed in three stages. The first stage is the output level of pollutant. The model explains output of polluted water (assumed to be equal to input of water), air pollutant (represented by the consumption of sulphur-containing resources), and output of waste. Output of waste is a function of non-primary production.[50]

The second stage is the pollutant removal rate, which consists of percentage of untreated polluted water and percentage of uncollected waste, both explained by the level of social capital stock as seen in equations #57 and #58.

Finally as the third stage, the actual level of water and air pollution is considered. Due to the difficulty of calculating national pollution level, the case of Tokyo is considered in the model. There are numerous factors to be taken into account in order to fully explain the situation of air and water pollution.[51] Included here are only the representative ones, judging from their causes and their influence on

environment. The water pollution level is represented by BOD (biological oxygen demand) which is considered to reflect the degree of pollution, and is estimated as a function of output of polluted water and diffusion rate of sewerage.

The air pollution level is described by sulphur dioxide level and carbon monoxide level. Sulphur dioxide is largely caused by industrial production activity and its level is explained in this model by output of air pollutant (which is assumed to be equal to consumption of sulphur containing resources) adjusted for sulphur content and the stock of pollution prevention capital. A positive sign is expected on the output of air pollutant and a negative sign on the pollution prevention capital stock. The carbon monoxide level is considered to be affected by exhaust gas from motor vehicles. It is therefore explained by the level of motor vehicle traffic, which is calculated by total transportation activity and the share of motor vehicles in it. A dummy variable is introduced to account for the implementation of regulation on the carbon monoxide emission level in 1970.[52]

The level of air and water pollution, together with the rate of utilization of land and water and various density indicators, determines the level of environmental pollution. This is a very complicated process and we have no theoretical or empirical grounds on which to define environment as a scalar. Reflecting this lack of knowledge, the general environmental condition function is left undefined, although its repercussions on the health of population and demand for pollution prevention investment is very real as has been pointed out in Sections 2.3.1 and 2.3.5.

3.3.8 Material Benefit Indicators

Material benefit indicators consist solely of definitions. Current consumption of food and non-durable goods is straightforward. Current consumption of these two items is evaluated in terms of constant prices.

Production of consumer durable goods is accumulated over a period of time and consumers enjoy the flow of service rendered by such stock; annual consumption of durable goods should be considered as an addition to the stock. First, the period for which the annual flow is to be accumulated must be determined. Theoretically, this should be the average life expectancy of the durable goods being produced in a particular economy, which, of course changes as the composition and quality of durable goods changes. Empirically, there are no data available on this point and estimation is too cumbersome to be included in the present study. The stock is calculated for the five year period under consideration. Second, it is necessary to estimate the flow of service which the stock of durable consumer goods renders each year. Theoretically, this could be the price of capital in that society, which is a variable to be explained in the system based on the demand and supply of capital. Empirically, this is very difficult especially when there had been capital rationing and the interest rates in the market did not represent market price of capital. As a first approximation, the imputed users' benefit rate of 10% is assumed.

The fourth item in material benefit is the service of housing capital. The imputed users' benefit rate of 10% is assumed again here.

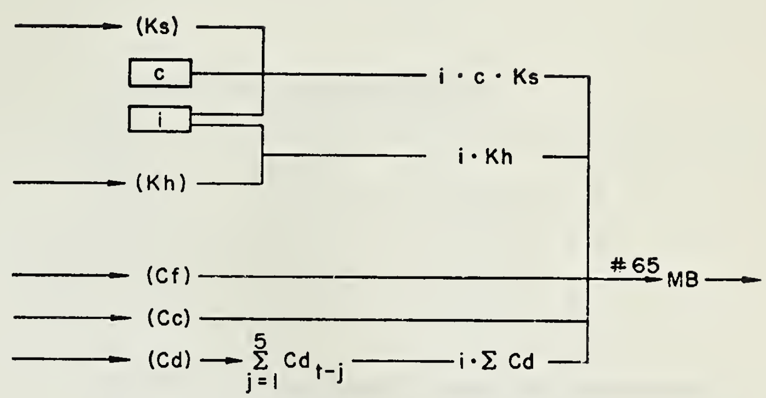

Figure 3-8. Flow Diagram of Material Benefit Indicator Equations

The same procedure is applied to estimate the benefit of social capital. The problem in this case is that part of the social capital stock is used solely as social overhead for production purposes. Harbors, for example, are used for transportation of goods for production purposes. Highways are shared by both producers and consumers. Still another category of social capital considered a cost item to the society, serving neither production nor consumption purposes, the sole purpose of which is to prevent possible damage to the society; flood control dikes are an example. In order to estimate the portion of social capital that benefits consumers directly, the ratio c is calculated, and is called the share of social capital for final use. The ratio c is estimated as follows: all cost items are excluded; social capital which merely supplement production capital is also excluded; and when the same social capital is shared by both producers and consumers, the weight of final use is estimated.[53]

Since all five components of material benefit are obtained in money terms, they can simply be added to obtain the total level of material benefit.

3.3.9 Density Indicators

Density indicators are obtained as definitions, i.e., as the ratio to habitable land. Population, gross national product, capital stock, and transportation activity are expressed as density indicators in this model. These indicators constitute a part of the general environmental indicator, together with input of land and water to economic activities and various pollution levels.

3.3.10 Energy and Transportation

Energy consumption is estimated as a function of real GNP and the rate of utilization of capital in non-primary sector. GNP in this case

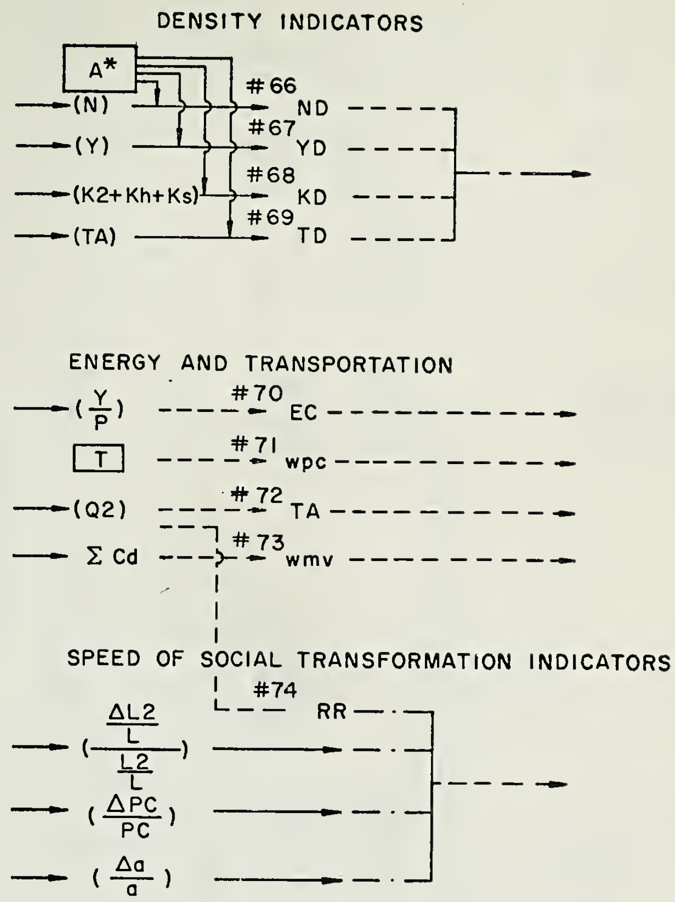

Figure 3-9. Flow Diagram of Density Indicators, Energy and Transportations Indicators, and Speed of Social Transformation Indicators Equations

Table 3-9

Energy and Transportation

		b₁	b₂	b₃	intercept	R	F	D.W.
#70. Energy consumption								
	a priori sign	+	+					
	log EC	$\log \frac{GNP}{P}$	log r					
1.		0.81356	0.24285		3.1988	0.9976	1936.89	1.190
	s	(0.013176)	(0.15950)		(0.029998)		2 & 18	
	t	(61.744)	(1.522)		(106.633)	S=0.019730		
2.		0.81055			3.1896	0.9973	3620.31	1.311
	s	(0.013471)			(0.030389)		1 & 19	
	t	(60.169)			(104.959)	S=0.020403		
#71. Share of petroleum and coal energy in total energy consumption								
	a priori sign	+						
	log wpc	T						
		0.0066307			-0.17546	0.9701	303.79	0.594
	s	(0.00038042)			(0.0047768)		1 & 19	
	t	(17.429)			(-36.732)	S=0.010556		

Table 3-9 (continued)

		b₁	b₂	b₃	intercept	R	F	D.W.
#72. Transportation activities								
	a priori sign	+	+					
	log TA	$\log \frac{GNP}{P}$	log r					
1.		0.74815	0.28337		3.9078	0.9967	1359.98	0.777
	s	(0.014448)	(0.17490)		(0.032894)		2 & 18	
	t	(51.780)	(1.620)		(118.800)	S=0.021635		
2.		0.74463			3.8971	0.9962	2503.26	0.735
	s	(0.014883)			(0.033574)		1 & 19	
	t	(50.032)			(116.076)	S=0.022541		
#73. Share of motor vehicle in total transportation activities								
	a priori sign	-	+					
	log wmv	$\frac{1}{\sum_{j=1}^{5} Cd_{t-j}}$	$\log \sum_{j=1}^{5} Cd_{t-j}$					
1.		-227.04			-0.35355	0.9262	114.80	0.091
	s	(21.189)			(0.027781)		1 & 19	
	t	(-10.714)			(-12.726)	S=0.095740		
2.			0.39256		-1.8949	0.9873	735.60	0.291
	s		(0.014474)		(0.050369)		1 & 19	
	t		(27.122)		(-37.619)	S=0.40316		

should be regarded as a variable representing the level of production and consumption activities for which energy is used. The rate of capacity utilization is included as a cycle variable. Both coefficients are estimated to be significant.

The share of petroleum and coal in total energy supply is considered as a function of technological change, and is estimated as a function of time trend.

Transportation activity function has a form analogous to energy consumption function. It is explained by real GNP and the rate of capacity utilization in non-primary sector. It was found that the elasticities of both functions with respect to real GNP and the rate of capacity utilization are somewhat comparable as follows:

	real GNP	capacity utilization
energy consumption	0.814	0.243
transportation activities	0.748	0.283

The share of motor vehicle transportation in total is estimates as a function of the stock of consumer durable goods. The assumption is made that automobiles constitute a large portion of the stock.

3.3.11 Speed of Social Transportation Indicators

Only one item of speed of social transformation indicators is in functional form. This is regional relocation of population explained as a function of the level of non-primary production.[54] Primary production is deemed to involve no regional relocation of population due to its close tie to the land. This is the reason why other variables such as GNP level are not used in the function.

Table 3-10

Regional Relocation of Population

	b_1	b_2	b_3	intercept	R	F	D.W.
#74. Regional relocation of population (1954-1970)							
a priori sign	+						
log RR	log Q2						
	0.28324			-0.022922	0.9392	112.26	0.692
s	(0.026732)			(0.050236)	S=0.030844	1 & 15	
t	(10.595)			(-0.456)			

Other indicators of speed of social transformation are derived by definitional relations. Examples are such items as the rate of inflation, the rate of change of the non-primary labor force ratio to the total, the rate of increase of capital stock, the rate of increase of input of land, and the rate of population increase.

3.4 Summary of the Model

(1) Sample observation period: 1950 through 1970.

(2) Sample data: Annual data series of sample size 21 unless otherwise stated.

(3) Estimation method: Ordinary least squares.

(4) System of the model:

behavioral equations	52
identities	22
total	74

The model as described in the previous section consists of 52 behavioral equations, of which 2 are not estimated (#45 and #50). Another (i.e., regional relocation of population), however, calculates a variable which is not used in other parts of the model. Seven identities express derived relations and also are not used as integral parts of the model. On the other hand, many other variables can be derived using the variables included in the model.[55]

(5) The total number of jointly dependent variables in the model amounts to 72, excluding the variables which are included only formally. The total number of exogenous variables is 21, of which 4 are constants and 5 are dummies.

3.5 Summary of Coefficients

Listed below are the coefficients of the most preferred functions which are used for a simulation test.

Production

#1. $\log \frac{Q1}{L1} = -2.5290 + 0.16838 \log \frac{K1}{L1} + 0.34308 \log \frac{A1}{L1} + 0.017185\ T$

#2. $\log \frac{Q2}{H \cdot L2^*} = -4.5992 + 0.34697 \log \frac{r \cdot K2^*}{H \cdot L2^*} + 0.033607\ T$

Prices and Wages

#3. $\log P1 = 1.1688 + 0.16400 \log \frac{W2}{L2 \cdot (1-u)} + 0.45707 \log P1_{t-1}$

#4. $\log P2 = 0.21849 + 0.092388 \log \frac{W2}{L2 \cdot (1-u)} + 0.50667 \log \frac{Pmr}{x}$

$+ 0.40433 \log P2_{t-1}$

#5. $\log Px = 0.45068 + 0.084543 \log \frac{W2}{L2 \cdot (1-u)} + 0.66583 \log \frac{Pmr}{x}$

$+ 0.13197 \log Px_{t-1}$

#6. $\log \frac{W2}{L2 \cdot (1-u)} = 5.0948 + 1.1428 \log \frac{Q2}{H \cdot L2^*}$

#7. $\log Ps = 0.94824 + 0.19774 \log \frac{W2}{L2 \cdot (1-u)} + 0.57287 \log Ps_{t-1}$

#8. $\log Pa = -3.0141 + 1.2648 \log(I2 + Ih + Is)_{t-1}$

#9. $\log P = 0.1132 \log P1 + 0.8868 \log P2$

#10. $\log Pc = 0.1847 \log P1 + 0.4945 \log P2 + 0.2947 \log Ps$

$+ 0.0261 \log Pa$

GNP-GNE

#11. $\log Y1 = -5.1113 + 1.3549 \log Q1 + 1.1957 \log P1$

#12. $\log Y2 = -2.23884 + 1.1086 \log Q2$

#13. $\log Yindex = 0.1132 \log Y1 + 0.8868 \log Y2$

#14. $\log Y = \log Yindex + \log Y_{1965}$

#15. $\log Y^* = \log Y + \log(1 - \frac{YM}{Y} - \frac{YRD}{Y})$

#16. $\log Cf = 2.3116 + 0.30048 \log \frac{Y^*}{P}$

#17. $\log Cd = -0.99160 + 1.7877 \log \frac{Y^*}{P}$

#18. $\log Cc = 1.9198 + 0.74620 \log \frac{Y^*}{P}$

#19. $\log \frac{S}{Y^*} = -1.0956 + 0.24221 \log \frac{Y^*}{P} + 0.12473 \log \frac{(Y^*/P)}{(Y^*/P)_{t-1}}$

Capital Formation

#20. $\log I1 = 1.0775 + 0.78537 \log \frac{S}{P2}$

#21. $\log I2 = 1.7465 + 1.0257 \log \frac{S}{P2}$

#22. $\log Is = 1.4803 + 0.83987 \log \frac{S}{P2}$

#23. $\log Ih = 0.91351 + 1.1695 \log \frac{S}{P2}$

#24. $\log Rkh = -1.3905 + 1.1194 \log Ih$

#25. $\log \frac{Iz}{I2} = -3.2693 + 0.086048\ T$

#26. $K1_{t+1} = K1_t + 11_t$

#27. $K2^*_{t+1} = K2_t + I2_t \cdot (1 - \frac{Iz}{I2})$

#28. $Ks_{t+1} = Ks_t + Is_t$

#29. $Kh_{t+1} = Kh_t + Ih_t - Rkh_t - Rkh'_t$

#30. $Kz_{t+1} = Kz_t + Iz_t$

Foreign Trade

#31. $\log \frac{X}{Px} = 1.4592 + 3.0114 \log \frac{Yw}{Pw} - 0.80 \log \frac{x \cdot Px}{Pw}$

#32. $\log \frac{M}{Pm} = -0.67264 + 0.84657 \log \frac{Y}{P} - 1.4009 \log \frac{Pm}{x \cdot P}$

$+ 0.68764 \log \frac{Q2_t}{Q2_{t-1}}$

#33. $\log B = \log X \cdot Px \cdot x - \log M \cdot Pm \cdot \frac{1}{x}$

Population Status

#34. $\log b = -2.8543 - 0.88358 \log(\frac{MB}{N})_{t-1} + 1.2128\ D1$

$+ 0.98550\ D1 \cdot \log(\frac{MB}{N})_{t-1} - 0.12201\ D2$

#35. $\log da = -2.6614 - 0.41160 \log(\frac{MB}{N})_{t-1} + 0.40562\ D1$

$+ 0.33225\ D1 \cdot \log(\frac{MB}{N})_{t-1}$

#36. $\log db = -2.7929 - 1.0908 \log(\frac{MB}{N})_{t-1}$

#37. $N_{t+1} = N_t[1 + b(1-db) - da + e]$

#38. $\log LE = 1.8818 - 0.0033596 \frac{1}{(MB/N)_{t-1}}$

#39. $\log \frac{N^*}{N} = -1.8897 + 0.94912 \log LE$

#40. $\log \frac{E}{N^*_{t-1}} = -0.89179 - 0.012945 \frac{1}{(MB/N)_{t-1}}$

#41. $\log \frac{L}{N^*} = 0.13148 + 0.18847 \log(\frac{E}{N^*_{t-1}}) + 0.43277 \log(\frac{L}{N^*})_{t-1}$

$- 0.35872\ D5 - 0.31228\ D5 \cdot \log(\frac{E}{N^*_{t-1}})$

#42. $\log(\frac{L2}{L})_{t+1} = 0.061973 + 0.015748 \log \frac{Y2}{L2} + 0.85403 \log \frac{L2}{L}$

#43. $\log H = 2.3601 + 0.084096 \log \frac{W2}{L2 \cdot (1-u)} + 0.059567 \log \frac{Q2_t}{Q2_{t-1}}$

$- 0.096026\ D4 - 0.13791\ D4 \cdot \log \frac{W2}{L2 \cdot (1-u)}$

#44. $\log(1-u) = -0.018989 + 0.028140 \log \frac{Q2_{t-1}}{Q2_{t-2}} + 0.0064721 \log Q2_{t-1}$

$+ 0.36804 \log(1-u)_{t-1}$

#45. $\log(1-1) = f(Pc, Q2, \ldots)$

#46. $\log(1-ai) = -0.0011671 + 0.000044953\ T$

#47. $\log(1-at) = 0.00031079 - 0.000076447 \log TA \cdot wmv$

#48. $\log(1-ad) = 0.00072038 + 0.0010566 \log(\frac{MB}{N})_{t-1}$

#49. $\log(1-v) = -0.00033773 + 0.00071070 \log(\frac{MB}{N})_{t-1}$

#50. $\log(1-az) = f(Z)$

#51. $\log L2^* = \log L2 + \log(1-m) + \log(1-u) + \log(1-1) + \log(1-ad)$

$+ \log(1-ai) + \log(1-at) + \log(1-av) + \log(1-az)$

#52. $L = L1 + L2e + L2u$

Environment

#53. $\log A2hs = 2.6923 + 0.27957 \log(K2+Kh+Ks)$

#54. $\log Zwater = -1.3475 + 1.1796 \log(r \cdot K2+Kh)$

#55. $\log Zair = 1.0366 + 0.81430 \log EC \cdot wpc$

#56. $\log Zwaste = 3.2549 + 0.73099 \log Q2$

#57. $\log(1-zwater) = 0.58141 - 0.15249 \log Ks$

#58. $\log(1-zwaste) = 4.8171 - 1.2049 \log Ks$

#59. $\log ZBOD = -6.3693 + 1.6543 \log Zwater \cdot (1-zwater)$

#60. $\log ZSO2 = -5.1352 + 2.3618 \log Zair \cdot Zs - 1.0018 \log Kz$

#61. $\log ZCO = -1.8772 + 0.46096 \log TA \cdot wmv - 0.29816\ D8$

#62. $\log a = \log A2hs - \log A^*$

#63. $\log w = \log Zwater - \log W$

#64. $Z = f(ZBOD, ZSO2, ZCO, \ldots, a, w, \ldots ND, YD, KD, TD, \ldots)$

Material Benefit

#65. $MB = Cf + Cc + i \cdot \sum_{j=1}^{5} Cd_{t-j} + i \cdot c \cdot Ks + i \cdot Kh$

Density

#66. $\log ND = \log N - \log A^*$

#67. $\log YD = \log GNP - \log A^*$

#68. $\log KD = \log(K2+Kh+Ks) - \log A^*$

#69. $\log TD = \log TA - \log A^*$

Energy and Transportation

#70. $\log EC = 3.1988 + 0.81356 \log \frac{GNP}{P} + 0.24285 \log r$

#71. $\log wpc = -0.17546 + 0.0066307\ T$

#72. $\log TA = 3.9078 + 0.74815 \log \frac{GNP}{P} + 0.28337 \log r$

#73. $\log wmv = -0.35355 - 227.04 \dfrac{1}{\sum_{j=1}^{5} Cd_{t-j}}$

Speed of Social Transformation

#74. $\log RR = -0.022922 + 0.28324 \log Q2$

3.6 Flow Chart of the Model

Now that the model is explained by equations, the flow of the entire model is shown on the next page. For a general relation among groups of equations, refer to Chart 1-2, "Outline of the Enlarged Economic System Model."

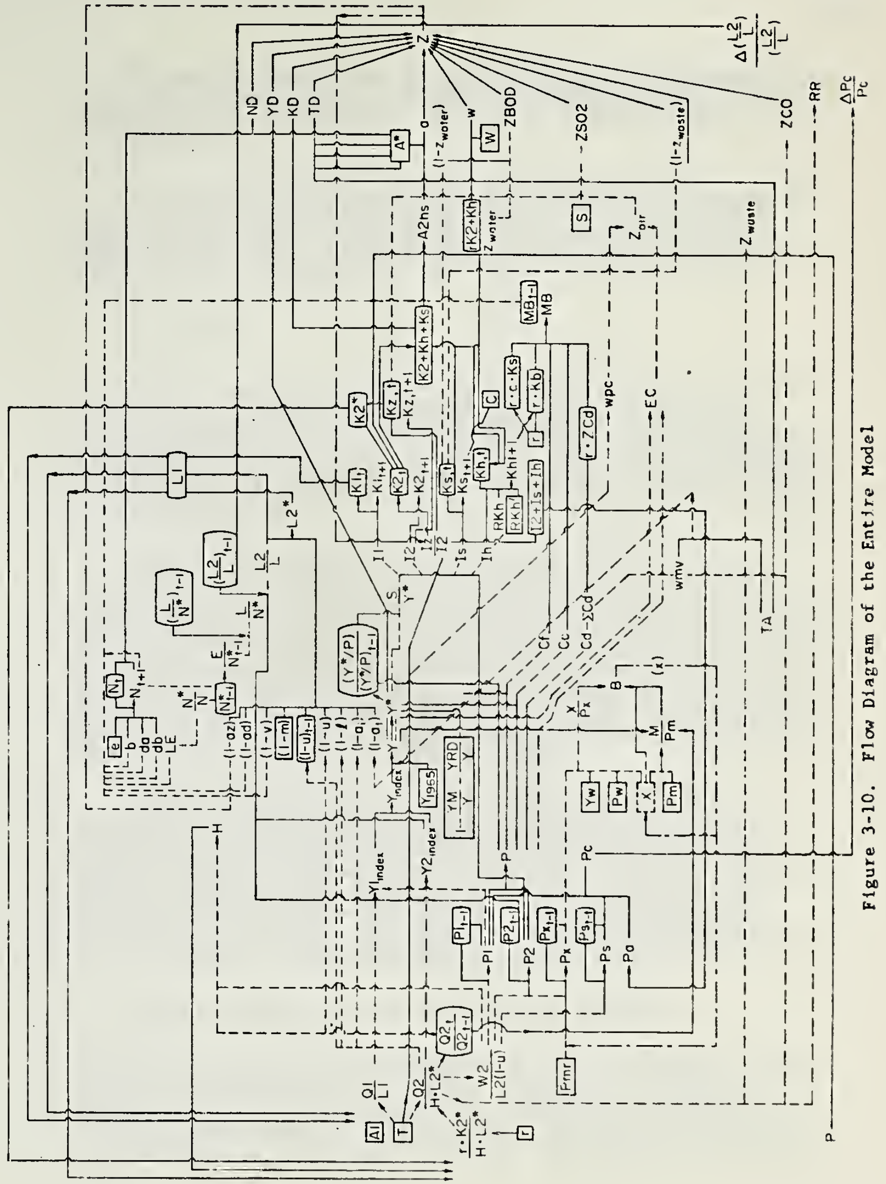

Figure 3-10. Flow Diagram of the Entire Model

FOOTNOTES FOR CHAPTER 3

[1] Goldberger (1964), pp. 359-360.

[2] For the problem of undersized samples, see Theil (1971), pp. 532-534.

[3] For example, Goldberger (1959).

[4] For example, EPA Medium-Term Model (see Appendix A of this study); U.S. Department of Commerce, p. 4.

[5] Notations are Goldberger's. Goldberger (1964), pp. 294-297, 364.

[6] R. G. D. Allen (1938), pp. 251-252.

[7] Similar treatment can be found, for example, in Ueno and Kinoshita (1965), and Niwa (1966) (1971). See especially Ueno and Kinoshita, pp. 41-42 and pp. 175-178. For alternative treatment of definitions, see ibid., pp. 174-175.

[8] Klein (1965).

[9] For Hicks neutral technical progress, see R. G. D. Allen (1968), pp. 239-240, and for homogeneous functions, see R. G. D. Allen (1938), pp. 315-316. We do not go into the problem posed by J. Robinson. See J. Robinson; Solow (1969); Champernowne; K. Sato (1970).

[10] Brubaker (1970), p. 102 and Blitzer (1970) make the same point. See also Arrow, Chenery, Minhas, and Solow; David and Van de Klundert; Kendrick and Sato; Kravis (1959). For synthesis, see Johansen.

[11] For rationale of the use of the Cobb-Douglas function, see Houthakker (1966), and Solow (1963). See also Uno (1971-3).

[12] For the improvement of quality of labor in Japan, see Watanabe and Egaitsu (1968).

[13] For disguised unemployment in agriculture, see Tohata; Ohkawa (1960).

[14] Economic Planning Agency (1964), p. 32; (1965), pp. 16-17. The elasticities are estimated by cross section analysis by region and farm size based on Noka Keizai Chosa, 1952, 1958, and 1960.

[15] Economic Planning Agency (1965-1), p. 13; Ueno and Kinoshita (1965), p. 35. For technical progress, Minami and Ishiwatari (196) for agriculture and R. Sato (1968) and K. Sato (1971) for manufacturing. See also Ohkawa (1968).

[16] A comprehensive review of empirical production function analysis of both agricultural and manufacturing sectors in Japan is given in Oyabu. For agricultural production function, especially inclusion of intermediate inputs, see Kaneda (1965), Hayami (1968), Saburo Yamada (1963), and Torii (1964-65).

[17] Ono (1965).

[18] See, for example, government consultation with Rice Price Council for F.Y. 1972 as reported in Nihon Keizai Shinbun, July 24, 1972. Kawakatsu indicates that rice price is 26 percent higher compared to eleven country average (countries included are U.S., France, W. Germany, Italy, Netherlands, Spain, U.K., Yugoslavia, Taiwan, India, and Japan) and that almost all agricultural prices are relatively expensive in Japan. See Kawakatsu (1970).

[19] Income compensation policy becomes necessary after the second stage of economic development in the Lewis-Ranis-Fei sense, i.e., only when the surplus labor is exhausted and labor market is competitive in the neo-classical sense. See Lewis; Fei and Ranis; Minami (1968) (1969-2), (1970); Torii (1967); Minami and Ono (1971); and Tsujimura (1969). Tsujimura argues that the rapid increase in government purchase price of rice and leaf tobacco which resulted from the changes of government price policy since 1960 resulted in the rise of agricultural income level and deterred labor mobility between agricultural and industrial sectors by assisting wage increase in the industrial sector.

[20] A common practice has been to use a Phillips-Lipsey type specification. See Phillips; Lipsey; Eckstein and Fromm; Simler and Tella. For Japanese case, Watanabe (1965-2), Ono (1969). Recent contribution by Maruo, that price rises and growth rates are inversely related, casts doubt on the wisdom of repeatedly resorting to this practice naively. See Maruo (1971-2), pp. 38-57; (1972); the same point is made in Harrod, p. 14; Macrae, p. 16; Schultze (1959) (1960). This point seems to require more empirical investigation.

[21] Minami and Ono (1971); Hirotaka Kato, pp. 104-120.

[22] As empirical works on consumption, see Mizoguchi (1969); Kaneda (1968); K. Sato (1970); Kuznets (1967). Although our definition of income and classification of commodities are different from theirs, and, therefore, direct comparison is not possible, their results summarized below indicate that our estimates of income elasticities are plausible.

Mizoguchi, pp. 342-343. (1950-1962)

food	clothing	furniture and utensils
0.3820	1.0058	2.0860

Mizoguchi, p. 337

	food	clothing	housing expenditure (other than rent)
1952-55	0.759	1.293	2.089
1955-58	0.717	1.163	2.529
1958-61	0.449	1.180	2.727
1961-64	0.543	0.943	1.845

Kaneda, p. 27. (1952-1962)

	food	clothing	furniture
rural	0.555	1.278	1.548
urban	0.462	1.073	1.386

For international comparison, see Mizoguchi (1969), pp. 342-343 for time series analysis and pp. 346-347 for cross section analysis. The same source gives prewar-post war comparisons for Japan. See p. 337.

[23]According to our calculations, Engel coefficient moved as follows.

	urban workers	farm household
1950	57.4	51.0
1955	44.5	47.2
1960	38.8	41.4
1965	36.3	35.8
1970	32.4	28.6

Hundred-Year Statistics of the Japanese Economy, p. 357 and p. 359; Japan Statistical Yearbook, various years.

[24]For diffusion of consumer durables, see Kokumin Seikatsu Hakusho 1971, pp. 444-445. Some of the items as of February 1964 and 1971 are as follows.

	1964	1971
Television receiver	87.8%	black and white 82.3% color 42.3%
Stereo	9.0	33.9
Tape recorder	8.7	33.4
Piano and organ	12.0	27.3
Camera	43.8	67.0
Automobile	--	38.2
Refrigerator	38.2	91.2
Washing machine	61.4	93.6
Vacuum cleaner	26.8	74.3

[25]For alternative forms of saving (and consumption) functions, see I. Yamada (1968), Shibuya (1969), Mizoguchi (1971). For saving function of farm household, see Shinohara (1968).

[26]The severity of natural disasters vary from year to year, but the fact that damages were in general more severe for years immediately following World War II presumably means that this item can be explained as a function of social capital.

[27]For such an attempt, see Uno (1971-4).

[28]An inclusion of cycle variable is seen in Branson.

[29]Houthakker and Magee, p. 113.

[30]See Leamer and Stern, Chapter 2, for other variables commonly used in import-demand analysis. An inclusion of the capacity-utilization variable "...represents an amendment to the traditional theory of demand insofar as it gives cognizance to the idea that queues as well as prices may be used to allocate goods among consumers." Ibid., p. 14.

Our attempt to distinguish food, non-primary finished goods and raw material imports gives the results shown below. These functions are not used in our model because of a data problem caused by different commodity classification for earlier years.

Food:

	b_1	b_2	b_3	b_0	R	F	D.W.
$\log \frac{Mf}{Pm1}$	$\log \frac{Y}{P}$	$\log \frac{Pm1}{x \cdot P1}$	$\log \frac{Q2_t}{Q2_{t-1}}$				
	0.68935 (0.16173)	-0.26840 (0.43910)		-1.0586 (0.39879)	0.957	99.27 2 & 18	0.420
					s=0.084155		

Non-primary finished goods:

$\log \frac{M2}{Pm2}$	$\log \frac{Y}{P}$	$\log \frac{Pm2}{x \cdot P2}$	$\log \frac{Q2_t}{Q2_{t-1}}$				
	1.2138 (0.058313)	-0.64361 (0.52252)	0.68016 (0.57875)	-2.1742 (0.15799)	0.984	176.00 3 & 17	1.386
					s=0.077574		

Raw materials:

$\log \frac{Mr}{Pmr}$	$\log \frac{Y}{P}$	$\log \frac{Pmr}{x}$	$\log \frac{Q2_t}{Q2_{t-1}}$				
	1.1262 (0.065369)		0.24877 (0.71102)	-1.5666 (0.15907)	0.971	150.23 2 & 18	1.980
					s=0.098160		

For food import, cycle variable has a wrong sign, and the coefficient on it is found to be insignificant. For non-primary import, income, relative price, and cycle variables have correct signs and plausible values. Inclusion of price term in raw material import results in wrong signs, presumably indicating availability theory is applicable, rather than price considerations. The cycle variable has a correct sign but is not significant. This can be improved by using trend value or moving average for income term. See Uno (1971-4).

[31] Houthakker and Magee, p. 113; Kinoshita (1969), p. 80; Takahashi, p. 53 and p. 62. Recent works concerning Japan's foreign trade include Ichimura and Eguchi (1964); Amano (1971); and Tanaka (1971).

[32] We cannot draw any conclusion on the balance of payments from simply looking at the trade balance; we would need a considerably more complex model which includes foreign investment and investment income receipt, freight and insurance receipt, and other non-trade receipts. See, for example, Tatemoto and Yajima. Japan's investment abroad is still very small compared with other major countries, reflecting rather tight restriction to investment abroad and limited availability of foreign currencies in the past. Tsusho Hakusho 1971, p. 366, gives the following figures for standing investment abroad as of end of 1969.

	U.S.	U.K.	W. Germany	Japan
	(million dollars)			
Total	70763	13405	4814	2683
Mining	5635	1054	200)	892
Petroleum	19985	(4200)	102)	
Manu-facturing	29450	7067	3558	722
Other	15693	5284	954	1070

[33] See, for example, Phelps Brown for theoretical aspect. For Japan's experience, see Keizai Kikakucho Chosakyoku (1971), p. 33, which says "...under tight money policy, a considerable improvement in trade balance was achieved through export drive and reduction of import or slower rate of increase of import." See the table below from the same source.

Tight money policy and balance of trade
(millions of dollars)

	Preceeding one year period	Following one year period
1957 I - 1958 II	(-)402	370
1961 III - 1962 IV	(-)504	79
1964 I - 1965 I	(-)357	872
1967 III - 1968 III	1538	1896
1969 III - 1970 IV	3560	3737

[34] Okazaki (1968), p. 6, observes that "upward trend in birth rate is mainly due to the acceleration of the intervals between marriage, the birth of the first child, and the birth of the second child; in other words, this phenomenon does not represent shift to fecundity, or enlargement of a family size." Actually, "it is becoming difficult to have even the second child. Birth pattern of the third child has undergone more radical change. It is now extremely rare for the married couples of our country to have the third child." (p. 23). For demographic experience of Japan, see Kuroda (1968), Aoki (1967) (1970), Yamaguchi (1966). For socio-economic factors affecting fertility, Okazak (April 1970), and Kono (1967). International comparisons are seen in Yamaguchi (1967) (1969).

[35] "Hinoe-uma" is the year of fire and horse according to Chinese calendar which assigns twelve animals for consecutive years, and wood, fire, earth, etc. for each round of five consecutive twelve year periods. Thus the process repeats every sixty years. Women born in the year of "Hinoe-uma" are supposedly stronger than men and are said to eat up men, making them bad matching mates.

For some observations on "Hinoe-uma", see Yamaguchi (1967), Okazaki (1968), pp. 1-2 and Aoki and Tomizawa (1968).

Actual number of births in 1966 was 1,359,000 as compared to 1,824,000 in the previous year, or a drop of 26%. As a result, the birth rate was 13.7% as compared to 18.6%.

[36] Kaneko.

[37] Oniki attempts to derive demand function for education.

[38] Sasaki (1957) points out fluctuation of labor force participation rate in response to demand for labor. This point may require further elaboration of our function.

[39] Related articles include Masui; Inoue; Torii (1966); Namiki (1957) (1959) (1960) (1962); Minami (1962) (1963).

[40] See Todaro.

[41] See Nadiri and Rosen.

[42] An estimate of the function of labor disputes was attempted in this study, but it requires further empirical investigation.

[43] Total cases are reportedly as follows:

1960	21,621
1969	29,531
1970	30,796

Figures by industries are available. See Rodo Hakusho 1971, pp. 370-371.

[44]Some problems on the reliability of industrial accident statistics are pointed out in Matsuda.

[45]Actual number of deaths rose from 4,202 in 1950 to 16,765 in 1970, and injuries from 25,450 to 981,096. Yamaguchi (1968) shows the following results concerning automobile accidents:

Motor vehicle possession (per 1,000 persons)	$\log X = 1.64057 + 0.07040\,t$ ($t = 0$ in 1961, unit: one year)
Death rate due to motor vehicle accidents (per 100,000 persons)	$\log Y = 1.57737 + 0.03604\,t - 0.00381\,t^2$
"	$Y = 4.67556 + 0.16541\,X$

[46]For a detailed observation on the time trend of diseases in Japan, see Aoki and Tomizawa.

[47]See, for example, Kokumin Seikatsu Hakusho 1971, p. 148. Brief international comparisons are also made there, which shows the crime rate itself is among the lowest in the world. See p. 406.

[48]Elasticity is estimated for each category as follows:

Non-primary capital stock:	0.643
Housing capital stock:	0.452
Social capital stock:	0.127

[49]Elasticity is estimated as follows:

Industrial:	1.216
Household:	0.918

[50]Waste output elasticity with respect to non-primary production is as follows:

Industrial:	0.995
Household:	0.500

[51]Pollutants not included in the model have the following results. We note that NOX is increasing, whereas floating particles and dust are decreasing reflecting shift of energy source.

		b_1	b_2	b_3	b_0	R	F	D.W.
NO (1964-71)								
a priori sign		+						
#1 log NO		log TD·(share of MV)						
		0.43018			-1.6248	0.74580	7.52007	1.77515
	s	(0.15687)			(0.88235)		1 & 6	
	t	(2.74227)			(-1.84146)			
						S=0.090587		
NO2 (1964-1971)								
#1 log NO2		log TD·(share of MV)						
		0.39737			-1.6923	0.86570	17.946	2.00828
	s	(0.093801)			(0.52760)		1 & 6	
	t	(4.23628)			(-3.20755)			
						S=0.054167		
Floating Particle (1964-71)								
#1 log FP		log(energy supply)·(share of coal)						
		-2.3287			10.529	0.61042	3.5634	1.66286
	s	(1.2336)			(5.8951)		1 & b	
	t	(-1.88772)			(1.78608)	S=0.16917		
Smoke Dust (Kawasaki City) (1961-69)								
#1 log SD		log(energy supply)·(share of coal)						
		-0.56058			4.5305	0.67296	5.79408	1.03151
	s	(0.23289)			(1.2335)		1 & 7	
	t	(-2.40709)			(3.67279)	S=0.071555		
#2		-0.50022			4.0124	0.60849	2.3518	1.37337
	s	(0.32618)			(1.7461)		1 & 4	
	t	(-1.53357)			(2.29800)	S=0.060978		

[52] As for the content of the regulation, see Kogai Hakusho 1971, pp. 214-216.

[53] More specifically, we follow the procedure explained below. We can obtain the breakdown of administrative public investment by purposes which include (1) road and highways, (2) urban development, (3) harbors, (4) agriculture and forestry, (5) public housing, (6) environmental and sanitary facilities, (7) welfare facilities, (8) maintenance of rivers, mountains, and sea shores, (9) educational and cultural facilities, and (10) others. Of these, a part of (1), all of (2), (5), (6), and (7) can be considered to constitute final use. As for (1), we calculate the relative share of cargo transportation and passenger transportation based on the indexes of transportation activities, which gives 55.5% for cargo and 44.4% for passenger transportation. Apparently, not all cargo transportation is intermediate and not all passenger travel is final, but we disregard this point for brevity. Multiplying the weight obtained with (1) would give the part of (1) used for final use. We remove (5) from both the numerator and the denominator because our model treats housing capital separate from social capital. Finally the ratio to the total is obtained. Thus we regard the ratio in flow as representing the use of stock. The ratio itself is changing over time (0.242 in 1960, 0.286 in 1965, 0.297 in 1969); we use the figure for 1965 throughout the period, another simplifying assumption.

[54] Jinko Mondai Kenkyujo (1969), pp. 4-17, estimates interprefectural movement for 1959-1967 period as follows:

$$Y = 37.948 - 14.186(0.5721)^t$$

where Y is the interprefectural migration rate, o/oo; and the origin is at 1959. See also Tachi and Misawa (1969); Ozaki and Suda (1970); Okazaki (1969); and Kuroda (1970-1) (1970-2). Kuroda (1), p. 28, points out that industrial plants are being located in rural areas as much as possible to overcome labor shortage. This may indicate that the cost of moving labor to urban industrial areas is becoming increasingly higher and the point is being reached where producers begin to consider locating new plants where the labor supply is concentrated, even on part-time basis.

[55] As Theil points out, the number of equations in a system is rather arbitrary if we include definitional equations, because none of them contains any unknown parameters and therefore can be omitted. See Theil, p. 477.

CHAPTER 4

SIMULATION ANALYSIS

The structural form presented in the preceeding chapter is judged to be sufficiently reliable as far as individual coefficients are concerned. In this chapter, the structural form is put into the reduced form and the system as a whole is tested by simulating the time paths of the endogenous set of variables. Then the experiment is extended to obtain projected values of the endogenous variables for the 1971-1985 period.

The projection will enable us to distinguish the problems of long run nature from more urgent ones, and provide basis for a policy simulation experiment in which a particular set of endogenous variables are treated as exogenous with experimental values assigned to them.

4.1 Reduced Form

The reduced form is required to take account of the mutual interdependence of the variables. In the reduced-form system, each current endogenous variable is expressed in terms of predetermined variables. Given the estimates of the structural coefficient matrices Γ and B, we may estimate the reduced-form coefficient matric Π by the derived reduced-form coefficient matrix

$$\hat{\Pi} = -\hat{B}\Gamma^{-1} \ . \quad ^1$$

The matrix $\hat{\Pi}$ consists of elements Π_{ij}, each of which shows how each of the endogenous variables is dependent on a particular predetermined variable. In other words, Π_{km} shows the impact effect of a predetermined variable x_{tk} on the endogenous variable y_{tm}, with all

other x_t's held constant. The model is specified in log-linear form except for time-trend variable and dummy variables. Therefore the reduced form coefficients show the elasticity of the endogenous variables with respect to the predetermined variables, after taking into account the interdependence among the current endogenous variables.

The estimate of reduced form coefficient matrix Π is shown in Table 4-1. In the model three different Π's are used: Π1 for 1950-1954, Π2 for 1955-1950, and Π3 for 1961-1970 and the prediction period. The one shown here is Π3. This procedure is necessary because dummy variables are used not only on the predetermined variables but also on some of the endogenous variables. Dummy variable D4 is used in the work hours function in the form $D4 \cdot \log \frac{W2}{L2(1-u)}$, which consists of the endogenous variables; and D5 is used in the labor force participation function as $D5 \cdot \log(\frac{E}{N^*_{t-1}})$, which is endogenous, too. D4 is zero for 1950-1960 and unity thereafter, and D5 is zero for 1959-1954 and unity thereafter, hence the need to use three reduced form coefficient matrices.

In the simulation test the share of pollution prevention investment is treated as exogenous, although the model includes this variable as endogenous. Therefore the Π matrices do not include this variable. An important application of an estimated reduced-form coefficient matrix is a simulation test for the sample period and for the future. Given the K x 1 vector x(*) of the predetermined variables for time t, the M x 1 vector $\hat{y}(*)$ of values of the endogenous variables for time t will be determined by

$$\hat{y}'(*) = x'(*)\hat{\Pi} \ .^{2}$$

Table 4-1

Reduced Form Coefficients

Predetermined \ Current Endogenous		log Q1 (1)	log Q2 (2)	log P1 (3)	log P2 (4)	log Px (5)	log W2 (6)	log Pm (7)	log Pa (8)	log Y1 (9)
constant	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log A1	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log E	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log inr	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
x	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log Xw	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log Yw	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log (1-Y1/Y-YRD/Y)	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log (1-m)	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log Q2 t-1	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log Q2 t-2	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log P1 t-1	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log P2 t-1	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log Px t-1	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log P t-1	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log Ye t-1	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log K1	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log K2*	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log Le	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log K1 t-1	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log L1	28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log L2 t-1	29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log L t-1	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log (1-u) t-1	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D1 log W2 t-1	36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D1 log N t-1	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D4	39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D5	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D6	41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log N	43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
log N* t-1	44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 4-1 (continued)

	log Y2	log Cf	log Cd	log Cc	log S	log I1	log I2	log Ie	log Ih
	10	11	12	13	14	15	16	17	18
1	-0.57790E 01	0.45585E 00	-0.11973E 02	-0.26629E 01	-0.92703E 01	-0.62994E 01	-0.79878E 01	-0.64985E 01	-0.10371E 02
2	-0.23171E-05	0.15812E-01	0.94065E-01	0.39265E-01	0.71925E-01	0.56486E-01	0.73774E-01	0.60408E-01	0.84116E-01
3	0.77243E-01	0.38122E-02	0.59378E-01	0.24357E-01	0.44949E-01	0.35302E-01	0.46104E-01	0.37752E-01	0.52568E-01
4	0.38414E 00	0.73024E-01	0.55245E 00	0.23101E 00	0.44306E 00	0.33468E 00	0.43736E 00	0.35812E 00	0.49868E 00
5	0.19785E-04	-0.12500E 00	-0.80321E 00	-0.33527E 00	-0.14435E 00	-0.52739E 00	-0.68877E 00	-0.56399E 00	-0.78534E 00
6	-0.19785E-04	0.12500E 00	0.80321E 00	0.33527E 00	0.14435E 00	0.52739E 00	0.68877E 00	0.56399E 00	0.78534E 00
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.30047E 00	0.17877E 01	0.74520E 00	0.13669E 01	0.10736E 01	0.14021E 01	0.11491E 01	0.15996E 01
12	0.77039E 00	0.21521E 00	0.12834E 01	0.53444E 00	0.93663E 00	0.76621E 00	0.10007E 01	0.81938E 00	0.11410E 01
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	-0.14275E-01	-0.53705E-02	-0.31957E-01	-0.13357E-01	-0.23373E-01	-0.19121E-01	-0.24972E-01	-0.20448E-01	-0.28473E-01
15	-0.21679E-01	-0.60560E-02	-0.36030E-01	-0.15034E-01	-0.26357E-01	-0.21561E-01	-0.28159E-01	-0.23057E-01	-0.32107E-01
16	-0.44584E-06	0.30424E-02	0.18101E-01	0.75554E-02	0.65584E-01	0.51505E-01	0.67246E-01	0.55079E-01	0.76697E-01
17	0.15789E-04	-0.10774E 00	-0.64097E 00	-0.26755E 00	-0.12155E 00	-0.42086E 00	-0.54965E 00	-0.45007E 00	-0.62671E 00
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	-0.34620E-17	-0.17710E-17	0.0	0.34620E-17	0.12473E 00	0.97959E-01	0.12794E 00	0.10476E 00	0.14587E 00
20	0.34620E-17	0.17710E-17	0.0	-0.34620E-17	-0.12473E 00	-0.97959E-01	-0.12794E 00	-0.10476E 00	-0.14587E 00
21	-0.11372E-05	0.77596E-02	0.46156E-01	0.19270E-01	0.35300E-01	0.27724E-01	0.36207E-01	0.29647E-01	0.41283E-01
22	0.36416E 00	0.93024E-01	0.55347E 00	0.23102E 00	0.45308E 00	0.33490E 00	0.43738E 00	0.35814E 00	0.49870E 00
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	-0.13615E-02	-0.38734E-03	-0.22628E-02	-0.94452E-03	-0.16553E-02	-0.13541E-02	-0.17685E-02	-0.14481E-02	-0.20164E-02
28	-0.32995E-05	0.22514E-01	0.13395E 00	0.55910E-01	0.10242E 00	0.80438E-01	0.10505E 00	0.86020E-01	0.11978E 00
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.28353E 00	0.79205E-01	0.47123E 00	0.19670E 00	0.34472E 00	0.28200E 00	0.36829E 00	0.30157E 00	0.41992E 00
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.13363E-01	0.37330E-02	0.22209E-01	0.92703E-02	0.16247E-01	0.13291E-01	0.17359E-01	0.14213E-01	0.19791E-01
34	0.13615E-02	0.38034E-03	0.22626E-02	0.94452E-03	0.16553E-02	0.13541E-02	0.17685E-02	0.14481E-02	0.20164E-02
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	-0.73978E-01	-0.20666E-01	-0.12295E 00	-0.51320E-01	-0.89940E-01	-0.73576E-01	-0.96091E-01	-0.78682E-01	-0.10956E 00
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	-0.44035E-04	0.30047E 00	0.17876E 01	0.74517E 00	0.13669E 01	0.10735E 01	0.14020E 01	0.11480E 01	0.15986E 01
47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.77039E 00	0.21521E 00	0.12804E 01	0.53444E 00	0.93663E 00	0.76621E 00	0.10007E 01	0.81938E 00	0.11410E 01
49	0.77039E 00	0.21521E 00	0.12834E 01	0.53444E 00	0.93663E 00	0.76621E 00	0.10007E 01	0.81938E 00	0.11410E 01
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4-1 (continued)

	log Rkh	log X	log M	log b	log da	log db	log LE	log N*	log B
	19	20	21	22	23	24	25	26	27
1	-0.12655E 02	0.15318E 01	-0.77328E 01	-0.29543E 01	-0.25614E 01	-0.27929E 01	0.18818E 01	-0.10365E 00	-0.89179E 00
2	0.94160E-01	-0.21457E-07	0.44543E-01	0.0	0.0	0.0	0.0	0.0	0.0
3	0.59945E-01	0.54955E-03	0.56152E-01	0.0	0.0	0.0	0.0	0.0	0.0
4	0.55421E 00	0.67396E-02	0.55620E 00	0.0	0.0	0.0	0.0	0.0	0.0
5	-0.37911E 00	0.13317E 00	0.24910E 00	0.0	0.0	0.0	0.0	0.0	0.0
6	0.57911E 00	-0.43317E 00	0.11516E 01	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	[illegible]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	[illegible]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	-0.40090E 00	0.0	0.0	0.0	0.0	0.0	0.0
11	0.17845E 01	-0.34694E-17	-0.21204E-15	0.0	0.0	0.0	0.0	0.0	0.0
12	0.12772E 01	-0.71340E-02	0.10247E 01	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	-0.31973E-01	0.17809E-03	-0.71321E 00	0.0	0.0	0.0	0.0	0.0	0.0
15	-0.23590E-01	0.20075E-03	-0.28836E-01	0.0	0.0	0.0	0.0	0.0	0.0
16	0.85854E-01	0.41185E-09	0.81054E-01	0.0	0.0	0.0	0.0	0.0	0.0
17	-0.70154E 00	-0.14221E-06	0.15878E 00	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.25394E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.16779E 00	-0.10819E-18	0.27707E-16	0.0	0.0	0.0	0.0	0.0	0.0
20	-0.16779E 00	0.10819E-18	-0.27640E-15	0.0	0.0	0.0	0.0	0.0	0.0
21	0.45273E-01	0.10531E-07	0.21861E-01	0.0	0.0	0.0	0.0	0.0	0.0
22	0.55825E 00	0.57095E-02	0.55622E 00	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	-0.22572E-02	0.12608E-04	-0.18110E-02	0.46358E 00	0.41150E 00	0.10906E 01	0.0	0.0	0.0
28	0.13409E 00	0.30554E-07	0.63429E-01	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.47006E 00	-0.26256E-02	0.37715E 00	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.22154E-01	-0.12375E-03	0.17775E-01	0.0	0.0	0.0	0.0	0.0	0.0
34	0.22572E-02	-0.12608E-04	0.18110E-02	-0.46358E 00	-0.41160E 00	-0.10908E 01	0.0	0.0	0.0
35	0.0	0.0	0.0	0.12128E 01	0.40552E 00	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.98550E 00	0.33225E 00	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	-0.98550E 00	-0.33225E 00	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	-0.12201E 00	0.0	0.0	0.0	0.0	0.0
39	-0.12264E 00	0.68505E-03	-0.98402E-01	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10000E 01	0.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10000E 01
45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.17894E 01	0.40777E-06	0.84651E 00	0.0	0.0	0.0	0.0	0.0	0.0
47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.12772E 01	-0.71340E-02	0.10247E 01	0.0	0.0	0.0	0.0	0.0	0.0
49	0.12772E 01	-0.71340E-02	0.10247E 01	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0	0.0	0.0	-0.33596E-02	-0.31887E-02	-0.12945E-01

Table 4-1 (continued)

	log L	log(L2/L)$_{t+1}$	log H	log (1-u)	log (1-ai)	log (1-at)	log (1-ad)	log (1-v)	log A2hs
	28	29	30	31	32	33	34	35	36
1	0.13825E 00	-0.29406E-02	0.22278E 01	-0.18989E-01	-0.11671E-02	0.39024E-03	0.72038E-03	-0.33773E-03	0.25923E 01
2	0.0	-0.35[illegible]E-07	-0.19278E-06	0.0	0.0	-0.30075E-05	0.0	0.0	0.0
3	0.0	0.58552E-03	-0.65313E-04	0.0	0.45000E-04	-0.18665E-05	0.0	0.0	0.0
4	0.0	0.63494E-02	-0.71570E-03	0.0	0.0	-0.39345E-04	0.0	0.0	0.0
5	0.0	0.31158E-06	0.16461E-05	0.0	0.0	0.25681E-04	0.0	0.0	0.0
6	0.0	-0.31158E-06	-0.16451E-05	0.0	0.0	-0.25681E-04	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	-0.78063E-17	0.24704E-15	0.0	0.0	0.10164E-19	0.0	0.0	0.0
12	0.0	0.12[illegible]E-01	0.64096E-01	0.0	0.0	-0.40938E-04	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	-0.30274E-03	-0.61157E-01	0.34612E-01	0.0	0.10216E-05	0.0	0.0	0.0
15	0.0	-0.34140E-03	-0.18037E-02	-0.28140E-01	0.0	0.11120E-05	0.0	0.0	0.0
16	0.0	-0.70115E-08	-0.37096E-07	0.0	0.0	-0.57674E-06	0.0	0.0	0.0
17	0.0	0.24365E-06	0.13136E-05	0.0	0.0	0.20494E-04	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	-0.43774E-18	-0.21089E-17	0.0	0.0	0.42760E-21	0.0	0.0	0.0
20	0.0	0.43774E-18	0.21089E-17	0.0	0.0	-0.42260E-21	0.0	0.0	0.0
21	0.0	-0.17709E-07	-0.94614E-07	0.0	0.0	-0.14762E-05	0.0	0.0	0.0
22	0.0	0.60497E-02	-0.71452E-03	0.0	0.0	-0.17696E-04	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.27957E 00
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	-0.27441E-04	-0.13328E-03	0.0	0.0	0.72350E-07	-0.10566E-02	-0.71070E-03	0.0
28	0.0	-0.51960E-07	-0.27451E-06	0.0	0.0	-0.42827E-05	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.43277E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.44551E-02	0.23590E-01	0.36804E 00	0.0	-0.15067E-04	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.21044E-03	0.11118E-02	0.0	0.0	0.17345E-01	0.0	0.0	0.0
34	0.0	0.21441E-04	0.11328E-03	0.0	0.0	-0.72350E-07	0.10566E-02	0.71070E-03	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	-0.11350E-02	-0.20218E 00	0.0	0.0	0.39311E-05	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.10000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	-0.43277E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.0	-0.69345E-06	-0.36636E-05	0.0	0.0	-0.57156E-04	0.0	0.0	0.0
47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.0	-0.36159E-02	0.64096E-01	0.0	0.0	-0.40938E-04	0.0	0.0	0.0
49	0.0	0.12132E-01	0.64096E-01	0.0	0.0	-0.40938E-04	0.0	0.0	0.0
50	0.0	0.65403E 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	-0.15859E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4-1 (continued)

	log Zwater	log Zair	log Zwaste	log(1-zwater)	log(1-zwaste)	log ZBOD	log ZSO2	log ZCO	log EC
	37	38	39	40	41	42	43	44	45
1	-0.13475E 01	-0.57061E 00	0.94716E 00	0.58141E 00	0.48171E 01	-0.76365E 01	-0.64833E 01	-0.23577E 01	-0.17985E 01
2	0.0	0.34858E-01	-0.15277E-05	0.0	0.0	0.0	0.62328E-01	0.18146E-01	0.42808E-01
3	0.0	0.27033E-01	0.24555E-01	0.0	0.0	0.0	0.53846E-01	0.11762E-01	0.26567E-01
4	0.0	0.40235E 00	0.23327E 00	0.0	0.0	0.0	0.58164E 00	0.23739E 00	0.49472E 00
5	0.0	-0.29765E 00	0.13046E-04	0.0	0.0	0.0	-0.70299E 00	-0.15495E 00	-0.36553E 00
6	0.0	0.29765E 00	-0.13045E-04	0.0	0.0	0.0	0.70299E 00	0.15495E 00	0.36553E 00
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	-0.55511E-16	-0.16653E-15	0.0	0.0	0.0	-0.13111E-15	-0.41633E-16	-0.13878E-16
12	0.0	0.47443E 00	0.50794E 00	0.0	0.0	0.0	0.11206E 01	0.24700E 00	0.58269E 00
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	-0.17841E-01	-0.12676E-01	0.0	0.0	0.0	-0.27965E-01	-0.61639E-02	-0.14541E-01
15	0.0	-0.13357E-01	-0.14293E-01	0.0	0.0	0.0	-0.31535E-01	-0.69506E-02	-0.16397E-01
16	0.0	0.17077E-02	-0.29338E-05	0.0	0.0	0.0	0.15842E-01	0.34918E-02	0.82374E-02
17	0.0	-0.25753E 00	0.70410E-04	0.0	0.0	0.0	-0.56100E 00	-0.12365E 00	-0.29170E 00
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.34520E-17	-0.51929E-17	0.0	0.0	0.0	0.81764E-17	0.0	0.51929E-17
20	0.0	-0.34520E-17	0.51929E-17	0.0	0.0	0.0	-0.81764E-17	0.0	-0.51929E-17
21	0.0	0.17048E-01	-0.74976E-06	0.0	0.0	0.0	0.40406E-01	0.89059E-02	0.21010E-01
22	0.0	0.20510E 00	0.29328E 00	0.0	0.0	0.0	0.99442E 00	0.20677E 00	0.25188E 00
23	0.0	0.0	0.0	-0.15249E 00	-0.12049E 01	-0.15226E 00	0.0	0.0	0.0
24	0.0	0.41706E-16	0.0	0.0	0.0	0.0	-0.10018E 01	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.11796E 01	0.0	0.0	0.0	0.0	0.19514E 01	0.0	0.0	0.0
27	0.0	-0.83855E-03	-0.89767E-03	0.0	0.0	0.0	-0.19805E-02	-0.43652E-03	-0.10298E-02
28	0.0	0.49632E-01	-0.21754E-05	0.0	0.0	0.0	0.11723E 00	0.25840E-01	0.60957E-01
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.17463E 00	0.18694E 00	0.0	0.0	0.0	0.41244E 00	0.90906E-01	0.21445E 00
32	0.0	-0.78330E-16	0.0	0.0	0.0	0.0	0.23618E 01	0.0	0.0
33	0.0	0.98307E-02	0.88106E-02	0.0	0.0	0.0	0.39478E-01	-0.10465E 03	0.10107E-01
34	0.0	0.83855E-03	0.89767E-03	0.0	0.0	0.0	0.19805E-02	0.43652E-03	0.10298E-02
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	-0.45563E-01	-0.48775E-01	0.0	0.0	0.0	-0.10761E 00	-0.23718E-01	-0.55953E-01
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.29916E 00	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.0	0.66245E 00	-0.29033E-04	0.0	0.0	0.0	0.15646E 01	0.34485E 00	0.81353E 00
47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.0	0.47443E 00	0.50794E 00	0.0	0.0	0.0	0.11206E 01	0.24700E 00	0.58269E 00
49	0.0	0.47443E 00	0.50794E 00	0.0	0.0	0.0	0.11206E 01	0.24700E 00	0.58269E 00
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4-1

Reduced Form Coefficients

	log wpo	log TA	log wmv	log RR	log P	log Pc	log Y	log Y*	log L*
	46	47	48	49	50	51	52	53	54
1	-0.17546E 00	-0.68773E 00	-0.35355E 00	-0.91711E 00	0.72147E 00	0.18550E 00	-0.59207E 01	-0.59207E 01	-0.19383E-01
2	0.0	0.33364E-01	0.0	-0.59195E-05	0.17753E-06	0.17036E-06	0.52618E-01	0.52618E-01	-0.30076E-05
3	0.65307E-02	0.24432E-01	0.0	0.35456E-02	0.34615E-02	0.51573E-02	0.36516E-01	0.36516E-01	0.43133E-04
4	0.0	0.51454E 00	0.0	0.48130E-01	0.39676E-01	0.52773E-01	0.34946E 00	0.34946E 00	-0.39345E-04
5	0.0	-0.33613E 00	0.0	0.50546E-05	0.44931E 00	0.25055E 00	0.17305E-04	0.17305E-04	0.25681E-04
6	0.0	0.33614E 00	0.0	-0.50546E-05	-0.44931E 00	-0.25055E 00	-0.17305E-04	-0.17305E-04	-0.25681E-04
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	-0.55511E-16	0.0	0.12490E-15	0.11102E-15	0.11102E-15	0.22204E-15	0.10000E 01	0.10164E-19
12	0.0	0.53584E 00	0.0	0.19581E 00	-0.42400E-01	-0.56643E-01	0.67382E 00	0.67382E 00	0.99996E 00
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	-0.33725E-01	0.0	-0.40214E-02	0.10581E-02	0.14135E-02	-0.16815E-01	-0.16815E-01	0.34613E-01
15	0.0	-0.15078E-01	0.0	-0.55383E-02	0.11931E-02	0.15939E-02	-0.18961E-01	-0.18961E-01	-0.28139E-01
16	0.0	0.75751E-02	0.0	-0.11391E-06	0.51740E-01	0.64421E-01	0.61866E-01	0.61866E-01	-0.57874E-06
17	0.0	-0.26825E 00	0.0	0.40737E-05	-0.25856E 00	0.19994E 00	0.13810E-04	0.13810E-04	0.20494E-04
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	-0.34620E-17	-0.85549E-17	-0.69239E-17	-0.34620E-17	-0.17310E-17	0.42260E-21
20	0.0	0.0	0.0	0.34620E-17	0.85549E-17	0.69239E-17	0.34620E-17	0.17310E-17	-0.42260E-21
21	0.0	0.19320E-01	0.0	-0.23935E-06	0.62598E-07	0.82512E-07	0.25924E-01	0.25924E-01	-0.14761E-05
22	0.0	0.23163E 00	0.0	0.39140E-01	0.39677E-01	0.53272E-01	0.34948E 00	0.34948E 00	-0.17696E-04
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	-0.94699E-03	0.0	-0.34783E-03	0.74934E-04	0.10010E-03	-0.11908E-02	-0.11908E-02	-0.17672E-02
28	0.0	0.56056E-01	0.0	-0.64292E-06	0.18160E-06	0.24259E-06	0.74927E-01	0.74927E-01	-0.42827E-05
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.19721E 00	0.0	0.72435E-01	-0.15605E-01	-0.20847E-01	0.24799E 00	0.24799E 00	0.36802E 00
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.92946E-02	-0.22704E 03	0.34139E-02	-0.73547E-03	-0.98251E-03	0.11688E-01	0.11688E-01	0.17345E-01
34	0.0	0.94699E-03	0.0	0.34783E-03	-0.74934E-04	-0.10010E-03	0.11908E-02	0.11908E-02	0.17672E-02
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	-0.51454E-01	0.0	-0.18899E-01	0.40715E-02	0.54392E-02	-0.64704E-01	-0.64704E-01	0.30311E-05
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.16882E 00	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	0.0	0.23011E-01	0.0	0.0	0.0
46	0.0	0.74812E 00	0.0	-0.11250E-04	0.24235E-05	0.32376E-05	-0.38514E-04	0.99996E 00	-0.57150E-04
47	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.0	0.53584E 00	0.0	0.19581E 00	-0.42400E-01	-0.56643E-01	0.67382E 00	0.67382E 00	0.99996E 00
49	0.0	0.53584E 00	0.0	0.19581E 00	-0.42400E-01	-0.56643E-01	0.67382E 00	0.67382E 00	0.99996E 00
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4-1 (continued)

	log ND	log YD	log KD	log a	log w	log B	log GNP
	55	56	57	58	59	60	61
1	0.0	-0.59207E 01	0.0	0.26923E 01	-0.13475E 01	0.96276E 01	-0.59207E 01
2	0.0	0.52618E-01	0.0	0.0	0.0	-0.44562E-01	0.52618E-01
3	0.0	0.36516E-01	0.0	0.0	0.0	-0.52255E-01	0.36516E-01
4	0.0	0.34946E 00	0.0	0.0	0.0	-0.51594E 00	0.34946E 00
5	0.0	0.17305E-04	0.0	0.0	0.0	0.54950E 00	0.17305E-04
6	0.0	-0.17305E-04	0.0	0.0	0.0	-0.75080E 00	-0.17305E-04
7	-0.10000E 01	-0.10000E 01	-0.10000E 01	-0.10000E 01	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	-0.22114E 01	0.0
9	0.0	0.0	0.0	0.0	0.0	0.30144E 01	0.0
10	0.0	0.0	0.0	0.0	0.0	-0.59910E 00	0.0
11	0.0	-0.22204E-15	0.0	0.0	0.0	0.44409E-15	-0.22204E-15
12	0.0	0.67382E 00	0.0	0.0	0.0	-0.10675E 01	0.67382E 00
13	0.0	0.0	0.0	0.0	-0.10000E 01	0.0	0.0
14	0.0	-0.16815E-01	0.0	0.0	0.0	0.73429E 00	-0.16815E-01
15	0.0	-0.18961E-01	0.0	0.0	0.0	0.30043E-01	-0.18961E-01
16	0.0	0.61866E-01	0.0	0.0	0.0	-0.81054E-01	0.61866E-01
17	0.0	0.13810E-04	0.0	0.0	0.0	-0.19678E 00	0.13810E-04
18	0.0	0.0	0.0	0.0	0.0	0.25938E 00	0.0
19	0.0	-0.17310E-17	0.0	0.0	0.0	-0.27696E-16	-0.17310E-17
20	0.0	0.17310E-17	0.0	0.0	0.0	0.27696E-16	0.17310E-17
21	0.0	0.25924E-01	0.0	0.0	0.0	-0.21861E-01	0.25924E-01
22	0.0	0.34948E 00	0.0	0.0	0.0	-0.51597E 00	0.34948E 00
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.10000E 01	0.27957E 00	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.11796E 01	0.0	0.0
27	0.0	-0.11908E-02	0.0	0.0	0.0	0.18867E-02	-0.11908E-02
28	0.0	0.74927E-01	0.0	0.0	0.0	-0.63429E-01	0.74927E-01
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.24799E 00	0.0	0.0	0.0	-0.39290E 00	0.24799E 00
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.11688E-01	0.0	0.0	0.0	-0.14518E-01	0.11689E-01
34	0.0	0.11908E-02	0.0	0.0	0.0	-0.18867E-02	0.11908E-02
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	-0.64704E-01	0.0	0.0	0.0	0.10251E 00	-0.64704E-01
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.10000E 01	0.0	0.0	0.0	0.0	0.0	0.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	0.0	0.99996E 00	0.0	0.0	0.0	-0.84651E 00	0.99996E 00
47	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.0	0.67382E 00	0.0	0.0	0.0	-0.10675E 01	0.67382E 00
49	0.0	0.67382E 00	0.0	0.0	0.0	-0.10675E 01	0.67382E 00
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0	0.0	0.0	0.0

In the model some of the predetermined variables are lagged endogenous variables. The estimated values of lagged endogenous variables in period (t-1) are fed into the vector of the predetermined variables for period t. This method is sometimes called the "final test."[3] In the following simulation test, therefore, only the estimated parameters, the initial values of the lagged endogenous variables, and the annual time series data on the exogenous variables are used.

In *ex ante* extrapolation of the model to 1971-1985, no adjustment of the constant term is made. For simulation beyond the sample period, time series data on the exogenous variables are required. This will be discussed in the next section.

4.2 Estimation of Exogenous Time Series for Extrapolation to 1971-1985

The time paths of the exogenous variables used for *ex ante* extrapolation are obtained by fitting least square lines to the values observed during the sample period. In some cases, only recent figures are used in the calculation because of fluctuations caused by the Korean War, Suez Crisis, or other considerations which make the inclusion of earlier data inappropriate.[4] The result is shown below. The figures in parentheses are standard error of regression coefficients.

$$\log Al = \underset{(0.0030229)}{4.8146} - \underset{(0.00018049)}{0.0023183}\ T \qquad R = 0.97660$$

$$\log Pmr = \underset{(0.012177)}{2.0416} - \underset{(0.00076683)}{0.0022506}\ T \qquad R = 0.68027$$

$$\log Pw = \underset{(0.0087806)}{1.9204} - \underset{(0.00055295)}{0.0045145}\ T \qquad R = 0.93250$$

$$\log Pm = \underset{(0.0093415)}{1.9534} - \underset{(0.00055295)}{0.0025011}\ T \qquad R = 0.80239$$

$$\log Yw = \underset{(0.0036008)}{1.6530} - \underset{(0.00028677)}{0.021994}\ T \qquad R = 0.99839$$

$$YM/Y = \underset{(0.00047030)}{0.012798} - \underset{(0.000028836)}{0.00021279}\ T \qquad R = 0.92637$$

$$YRD/Y = \underset{(0.00071798)}{0.0073418} + \underset{(0.000044022)}{0.00036727}\ T \qquad R = 0.97218$$

$$\log(1-m) = \underset{(0.00009234)}{-0.0043646} + \underset{(0.0000056618)}{0.000070497}\ T \qquad R = 0.97218$$

As for the share of pollution prevention investment, it is treated exogenously but is assigned values given by the estimated function in the preceding chapter. That is,

$$\log I2/I2 = \underset{(0.23949)}{-3.2693} + \underset{(0.012198)}{0.086048}\ T \qquad R = 0.94467$$

Other assumptions made include the following:

r (rate of capacity utilization in non-primary sector): 1971 = .75, 1972 = .80, 1973 on = .8566. The last figure is the average of 1953-1970 period for which empirical data are available.

x (exchange rate): 1971 = 1.0310, 1972 on = 1.1688. The Japanese yen was revalued on December 19, 1971 from 360 yen to the dollar to 308 yen to the dollar, or by 16.88 percent. This revaluation rate is assumed for the *ex ante* simulation period. For 1971, the exchange rate shown here is calculated as the weighted average of the exchange rate in effect, the weight being the number of days for which a particular rate was in effect. The yen was floated from August 28, 1971, after the U.S. suspended convertibility to dollars to gold on August 15, to the formal revaluation of yen in December. A constant amount of upward change is assumed in the interim period.[5]

Zs (sulphur contents in fuels): constant at 0.015.

(1-1) (man year not lost due to labor disputes): constant at 0.999371, which is the average of 1950-1970.

Dummy variables: all but D2 are unity.

L2/L (labor allocation): calculated values are used when L2/L ≤ 0.95. When the calculated ratio exceeds 0.95, we assign 0.95 instead. This is done to avoid L2/L exceeding unity.

Some adjustments are necessary to take into account Okinawa which was transferred to Japanese jurisdiction on May 15, 1972. All the variables in the model are affected by this reversion. Due to the limited availability of data, however, only the following adjustments are made:

1) Okinawa's population of 945,000 is added to the calculated 1972 population figure.
2) Same sort of adjustment is made for labor force, which totals 380,000.
3) Of the estimated Okinawa's GNP of 400 billion yen in F.Y. 1972, the portion produced after May 15 to the end of calendar year is calculated using the number of days as the weight. The resultant figure approximately 252 billion yen, is added to 1972 GNP.[6]

4.3 Simulation Results

The simulation is divided into two periods. The first perios is the sample period from 1950 to 1970. The charts show the actual values in dotted lines and the estimates values in solid lines. The second period is the extrapolation period from 1971 to 1985. No adjustment of the constant term is made to remove the gap between actual and calculated

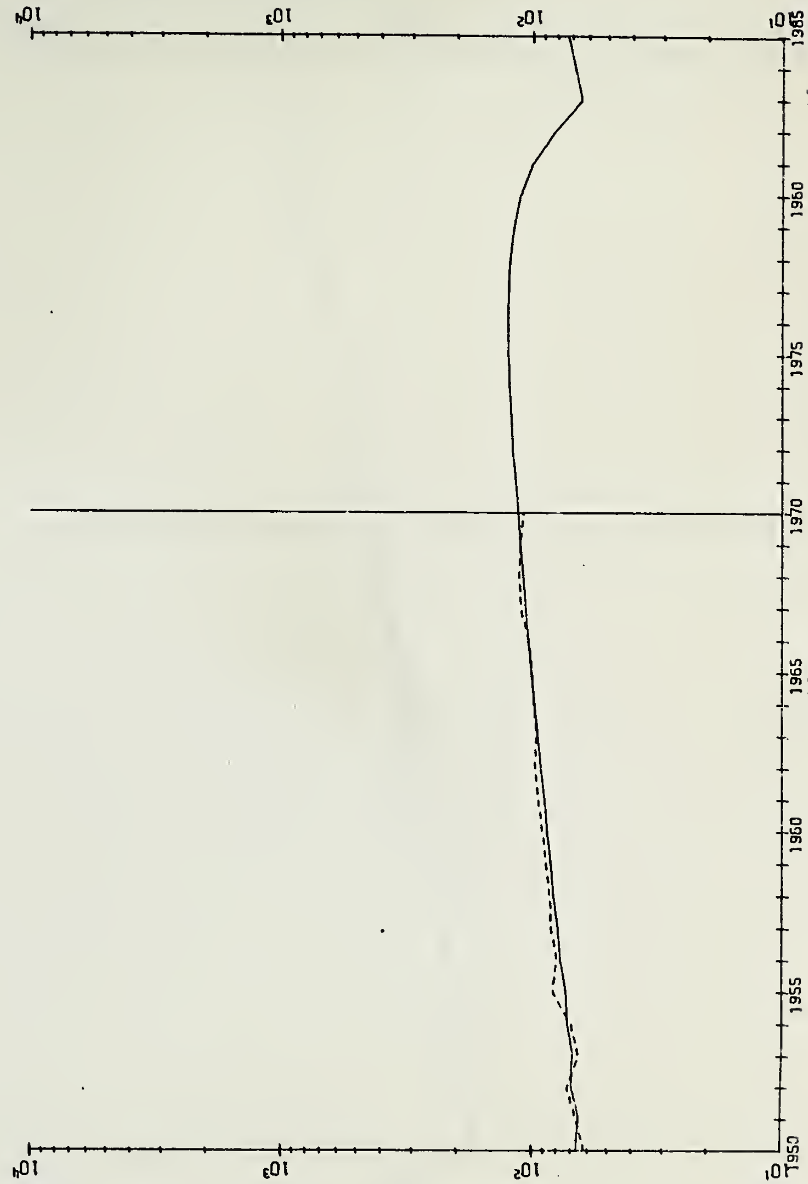

Figure 4-1. Primary Sector Output (Index, 1965 = 100)

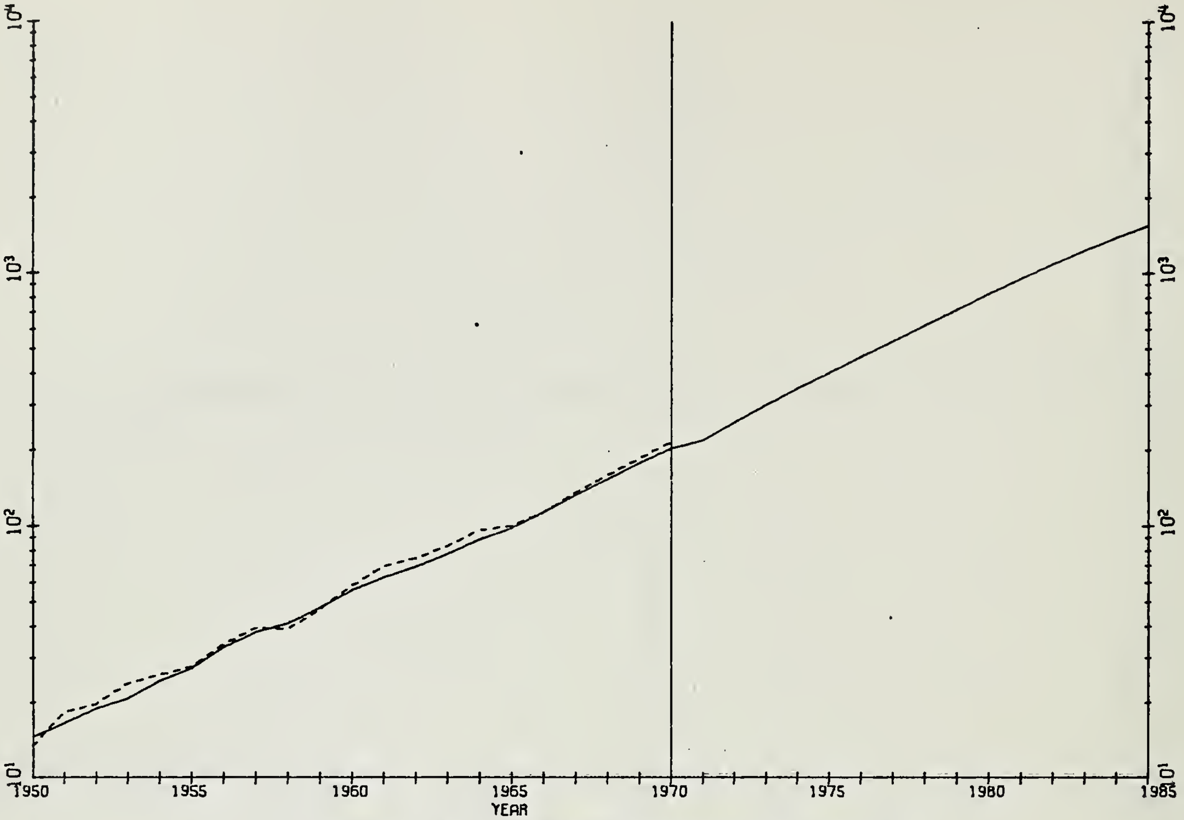

Figure 4-2. Non-Primary Sector Output (Index, 1965 = 100)

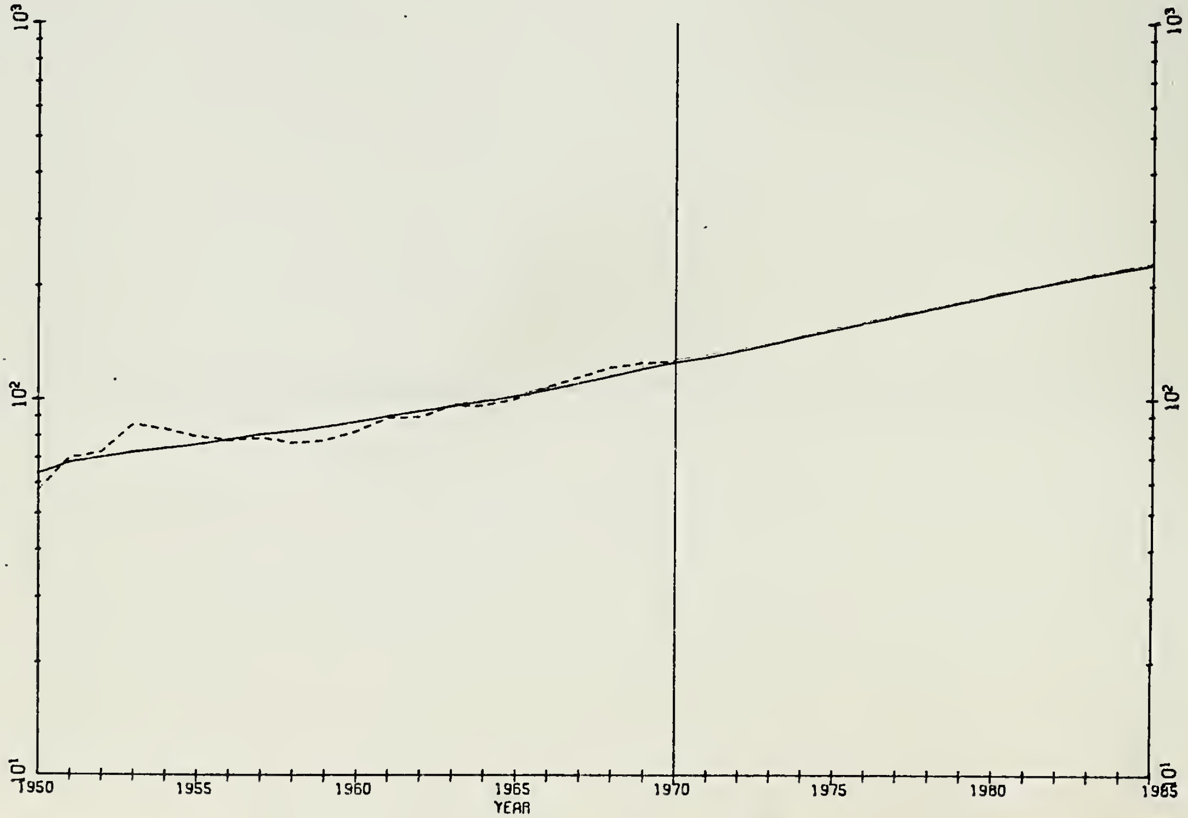

Figure 4-3. Primary Products Price Index (1965 = 100)

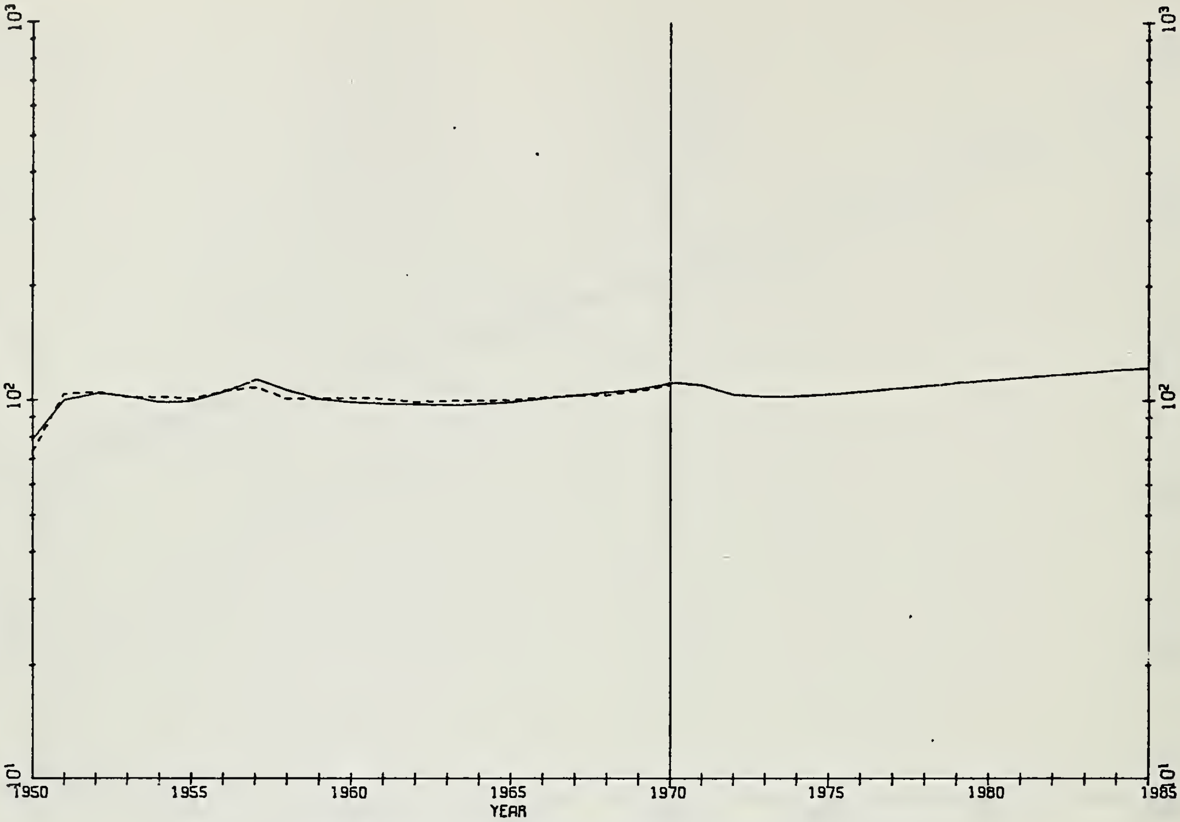

Figure 4-4. Non-Primary Products Price Index (1965 = 100)

175

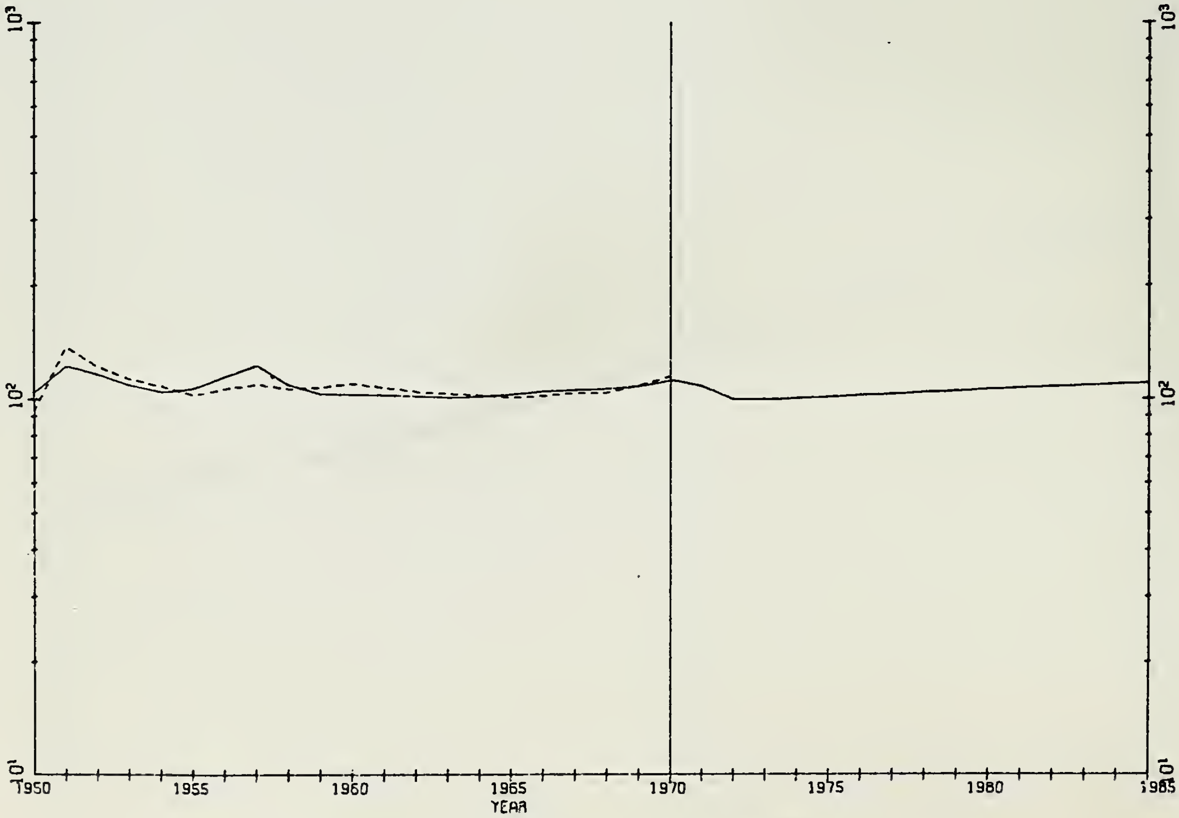

Figure 4-5. Japanese Export Price (Unit Value Index) (1965 = 100)

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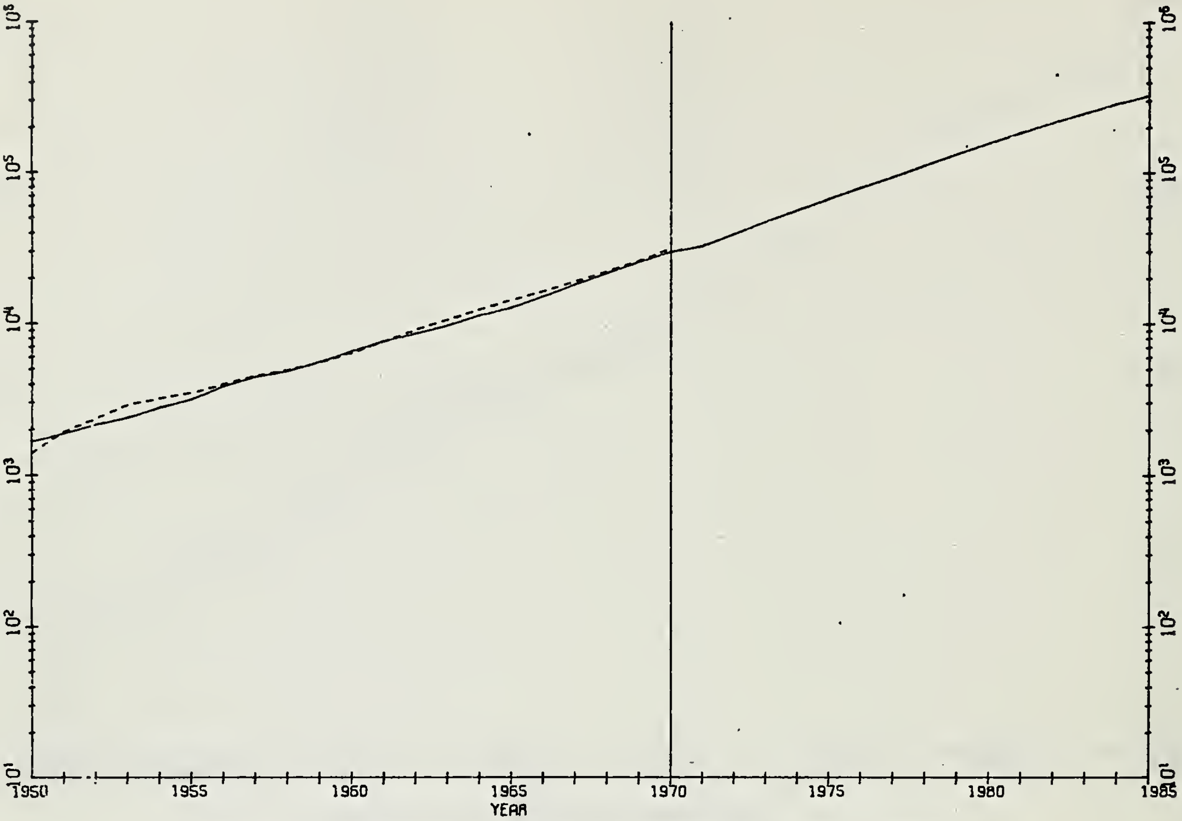

Figure 4-6. Compensation of Employees (Current Prices) (Billion Yen)

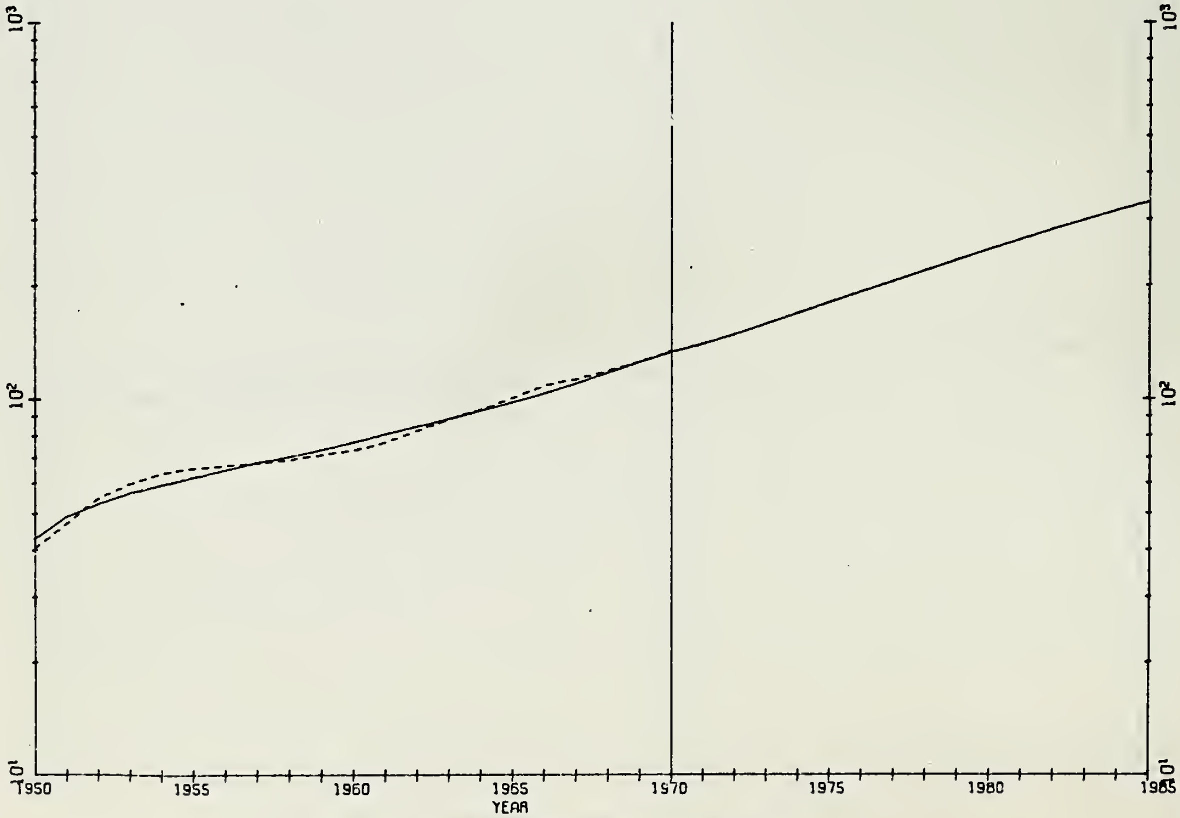

Figure 4-7. Service Price Index (1965 = 100)

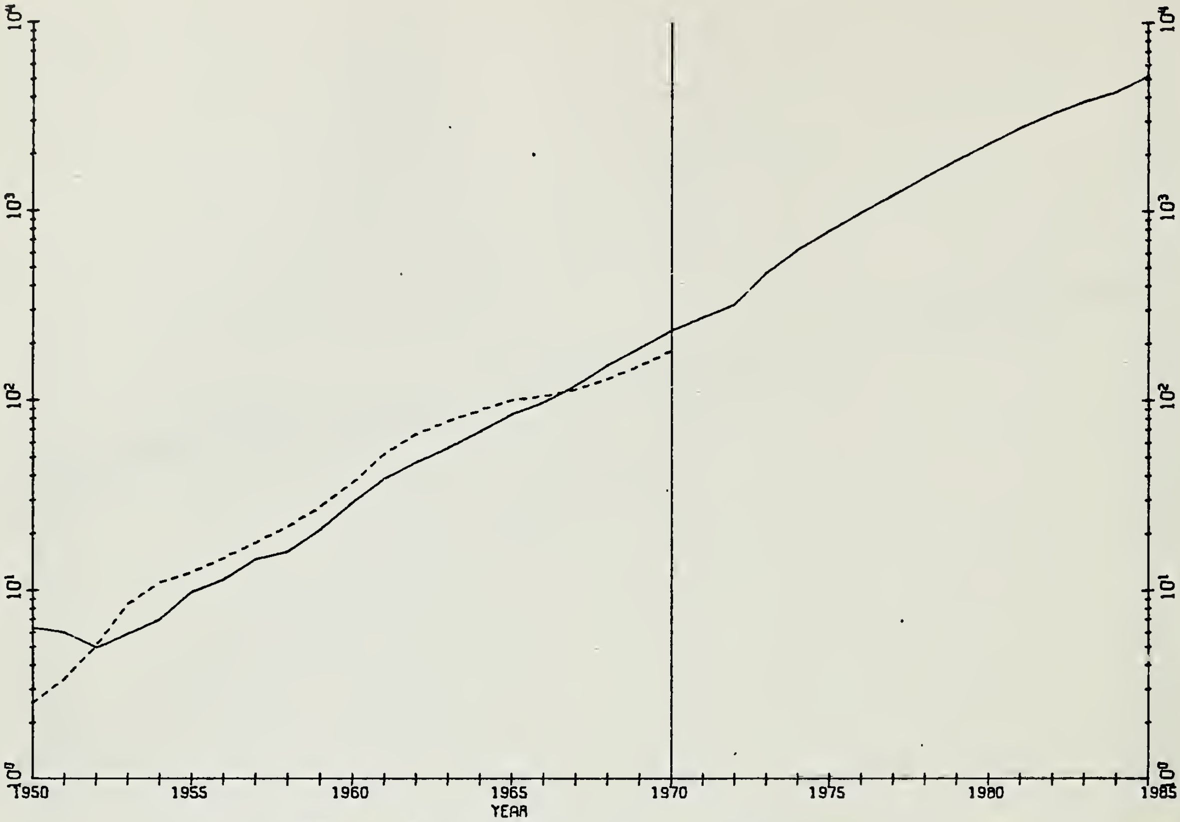

Figure 4-8. Land Price Index (1965 = 100)

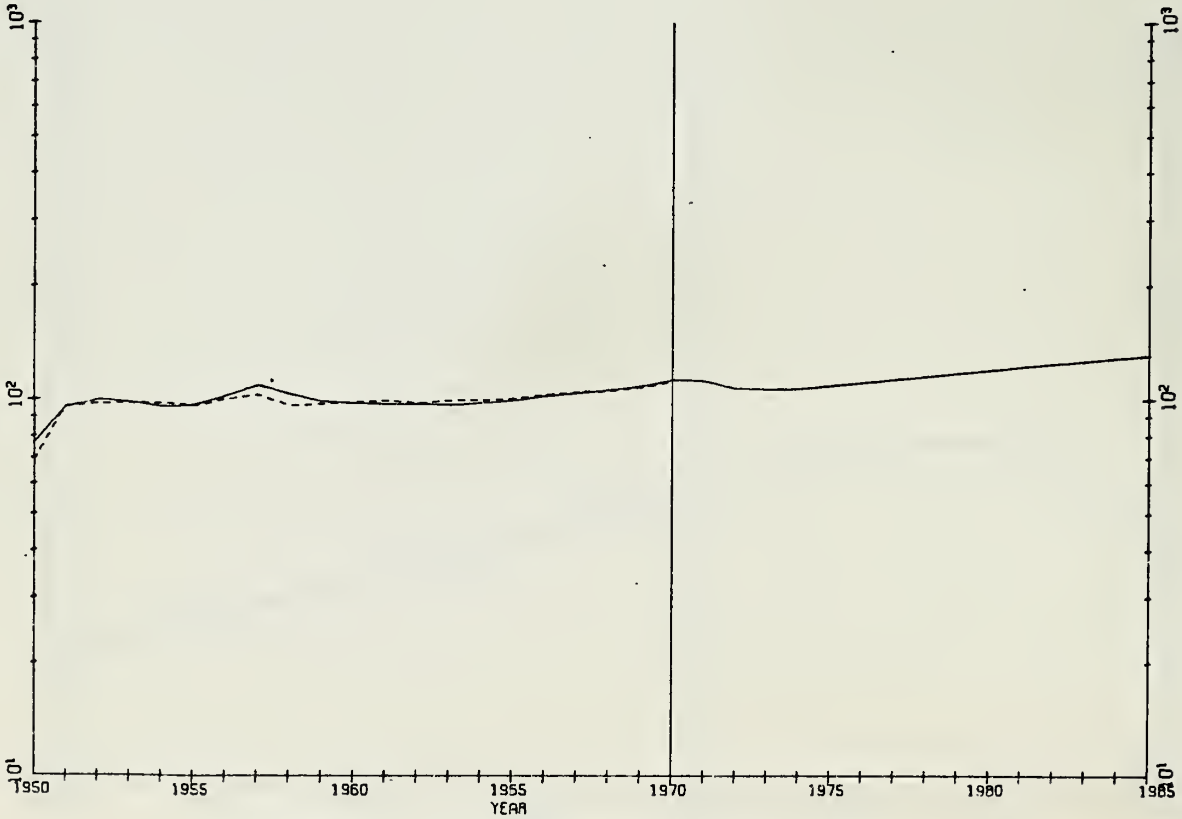

Figure 4-9. General Wholesale Price Index (1965 = 100)

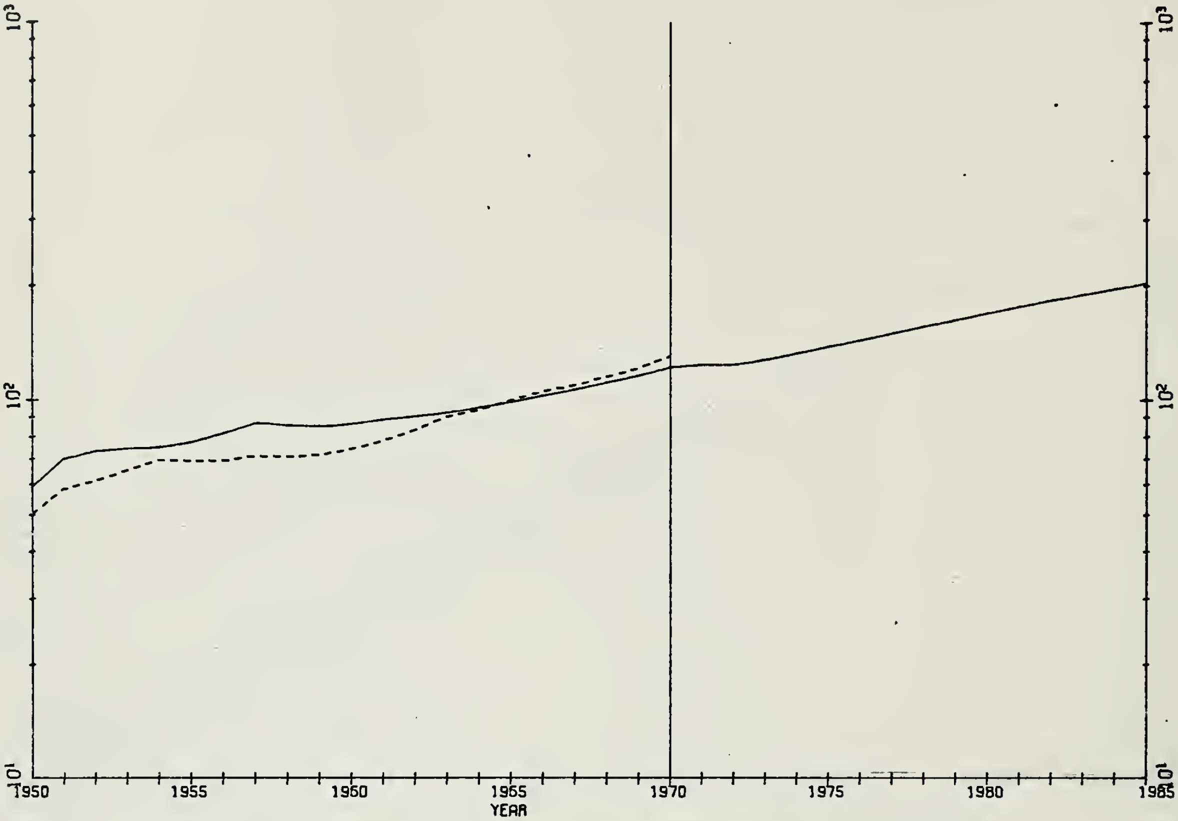

Figure 4-10. Consumer Price Index (1965 = 100)

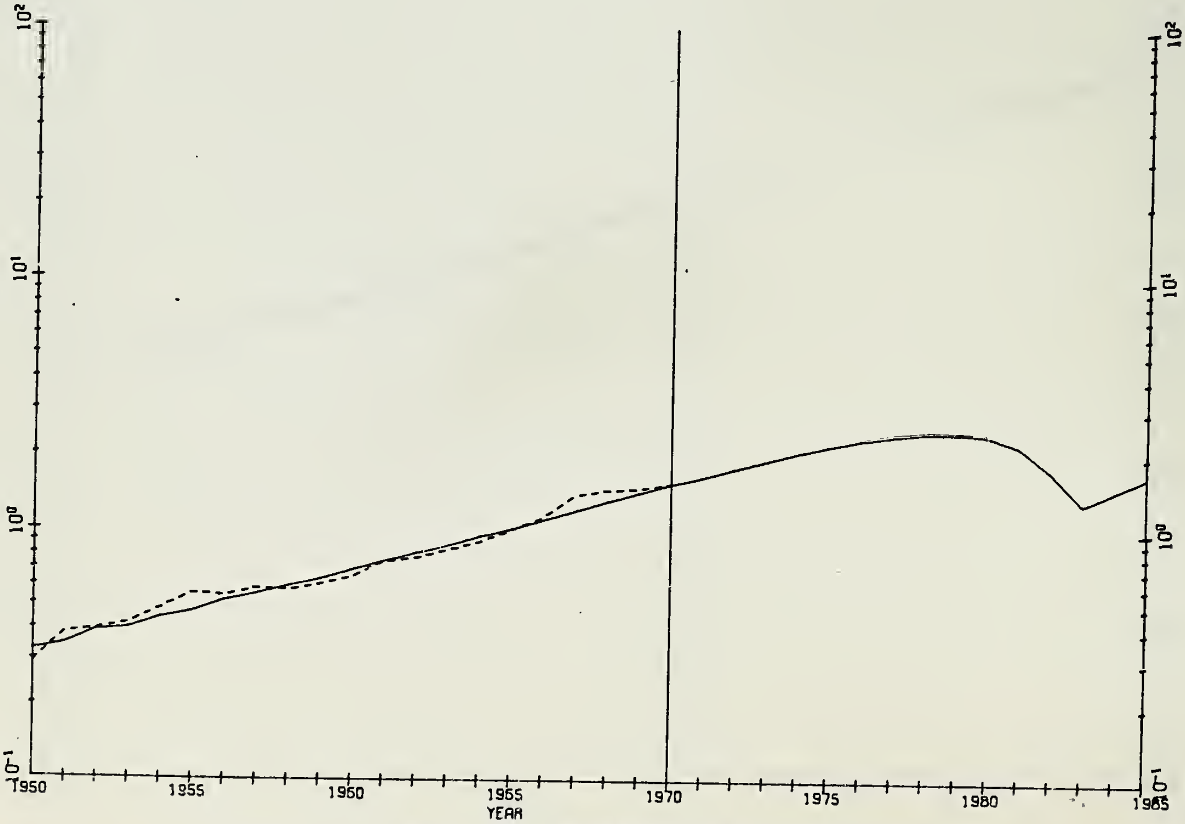

Figure 4-11. Value Added in Primary Sector (Current Prices, 1965 = 100)

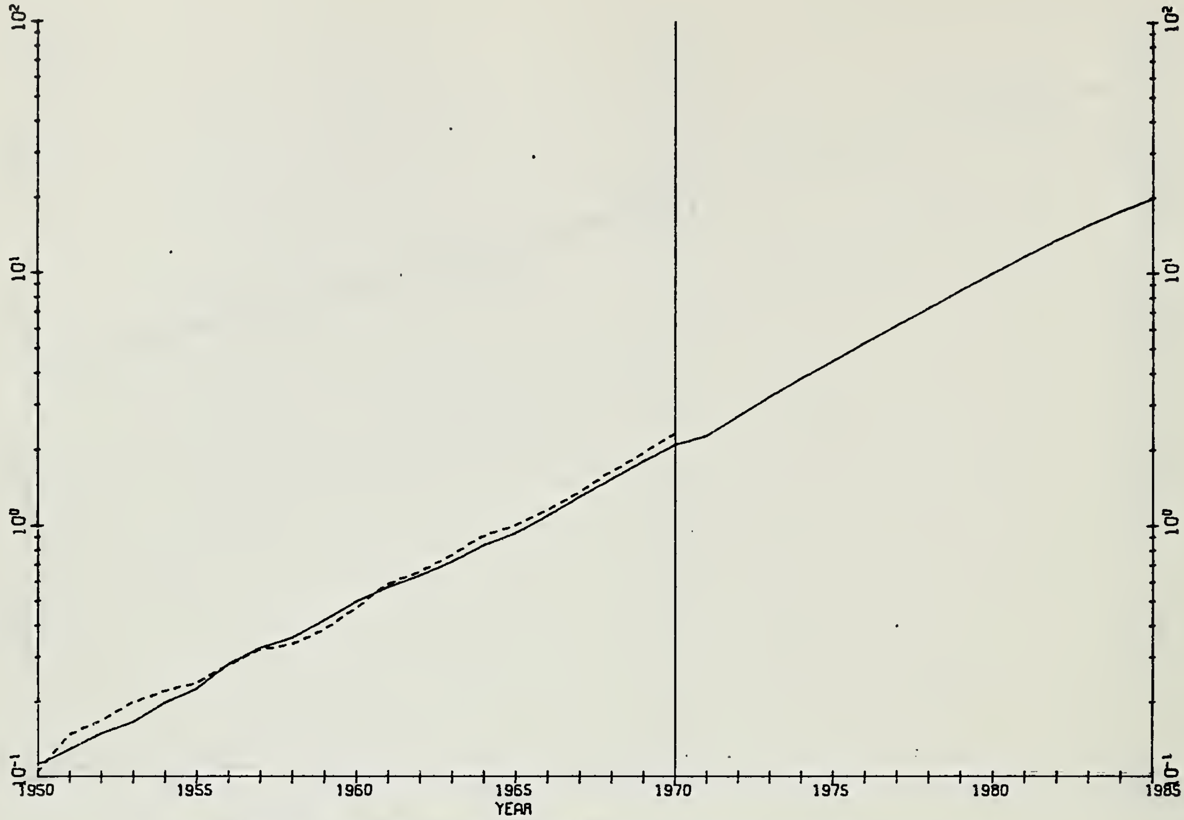

Figure 4-12. Value Added in Non-Primary Sector (Current Prices, 1965 = 100)

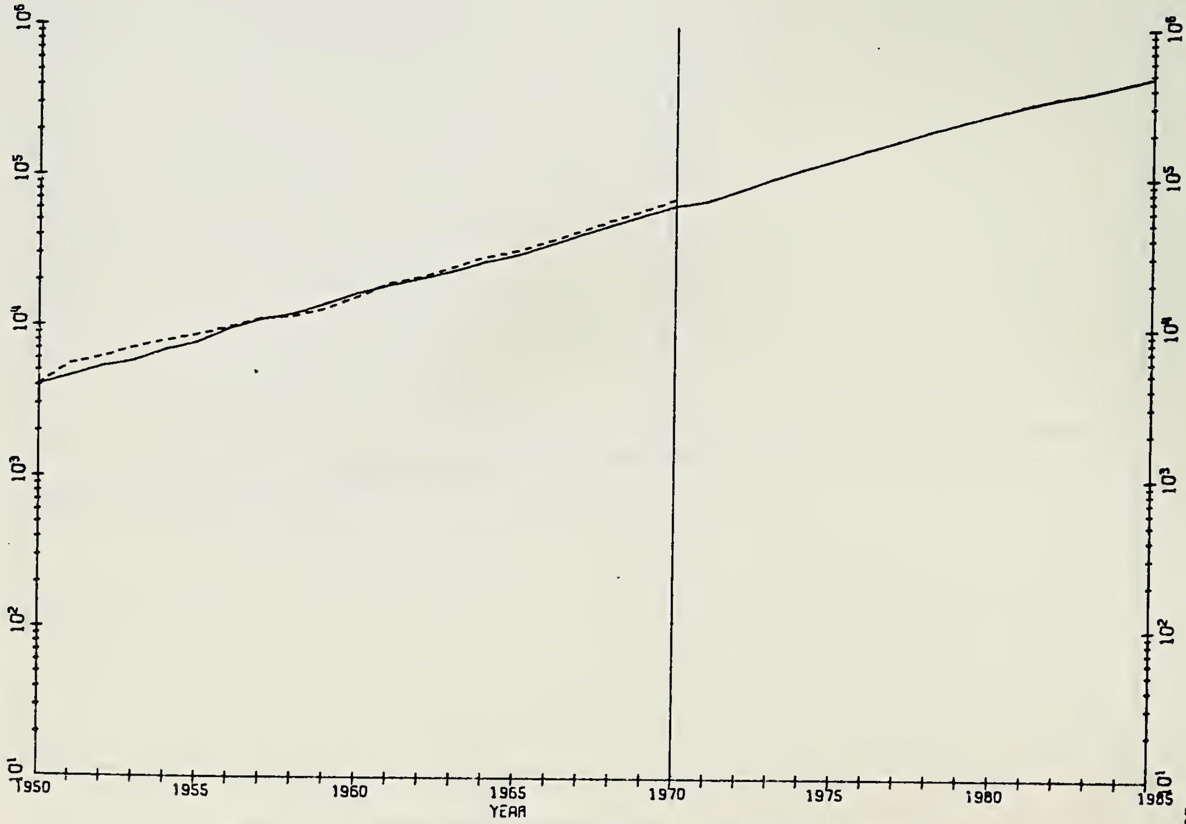

Figure 4-13. Gross National Product (Current Prices, Billion Yen)

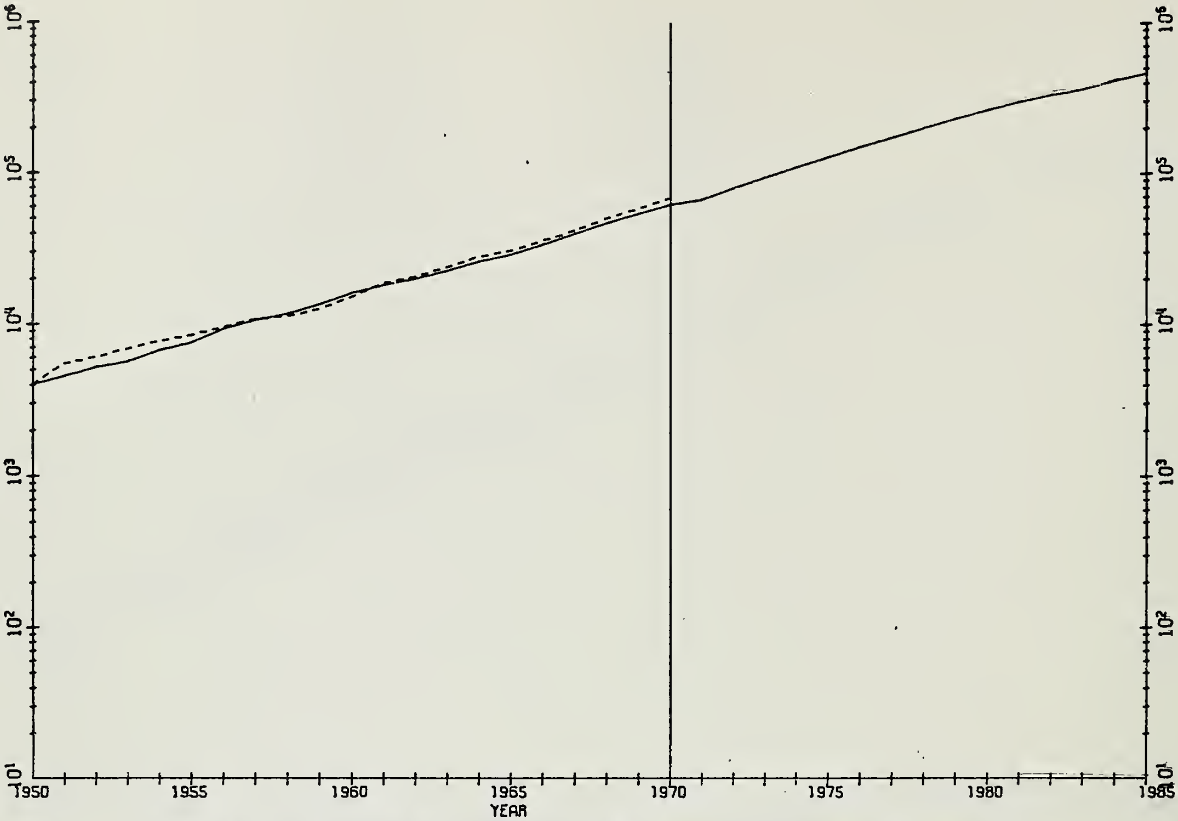

Figure 4-14. GNP Net of Military and R&D (Current Prices, Billion Yen)

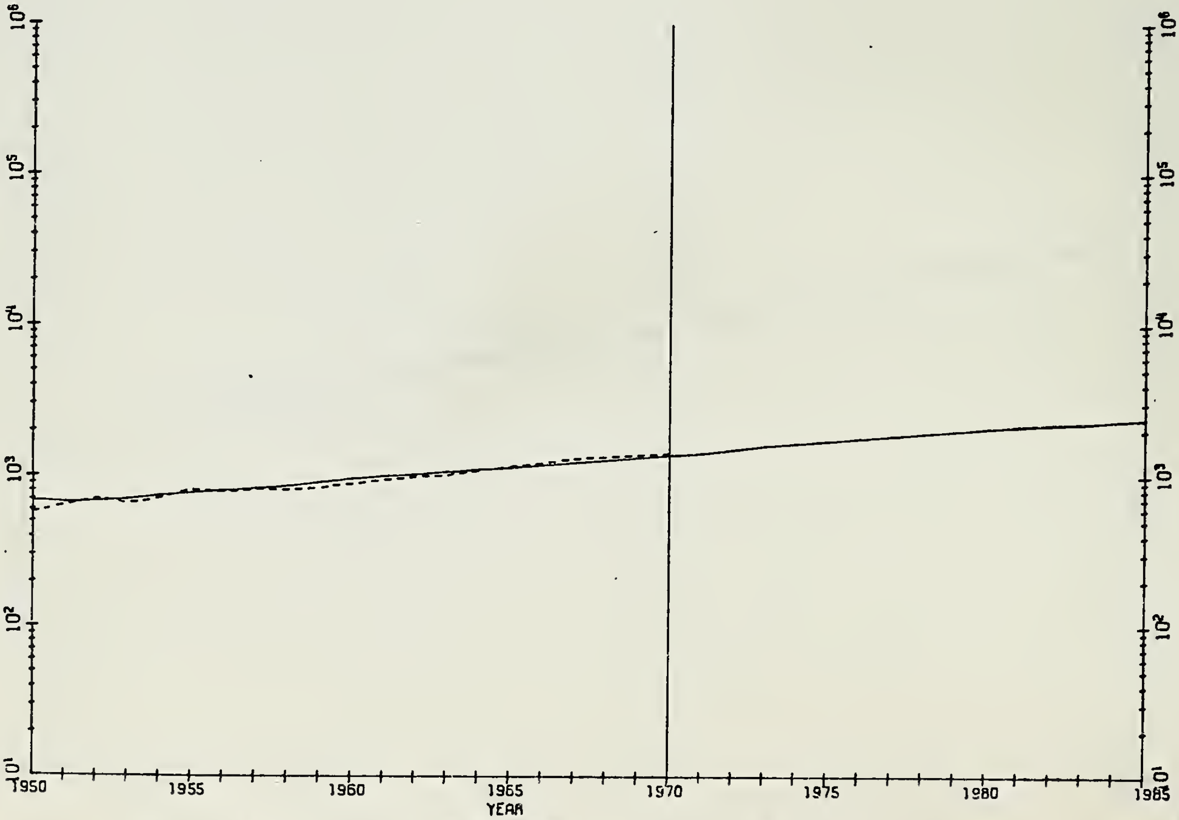

Figure 4-15. Consumption of Food (1965 Prices) (Billion Yen)

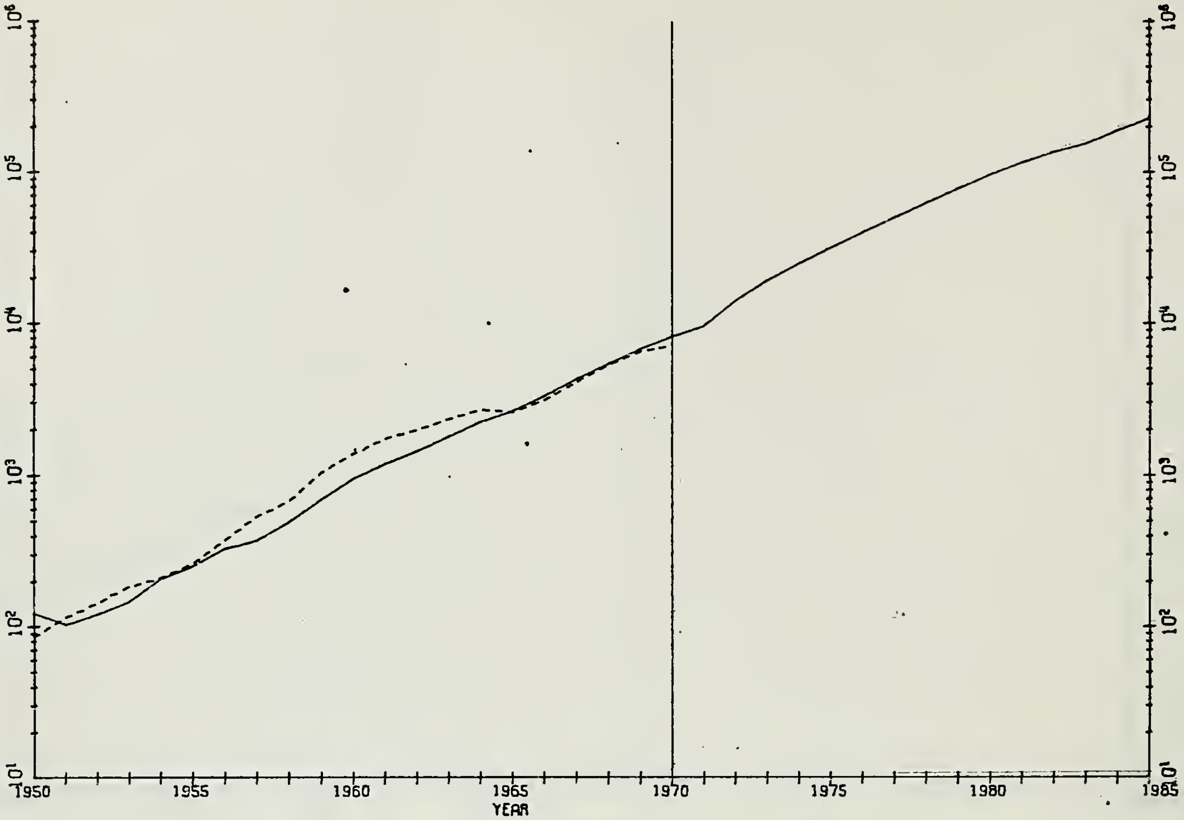

Figure 4-16. Consumption of Durable Consumer Goods (1965 Prices) (Billion Yen)

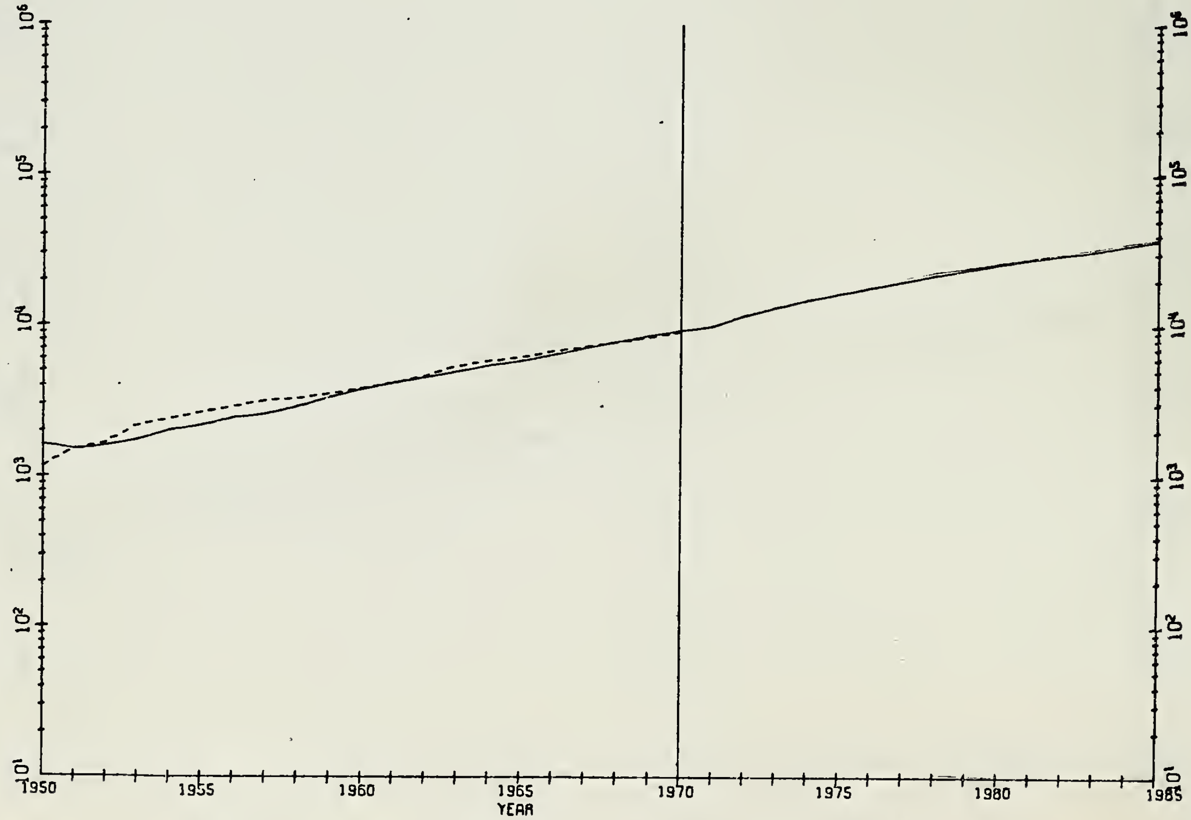

Figure 4-17. Consumption of Non-Durable Consumer Goods (1965 Prices) (Billion Yen)

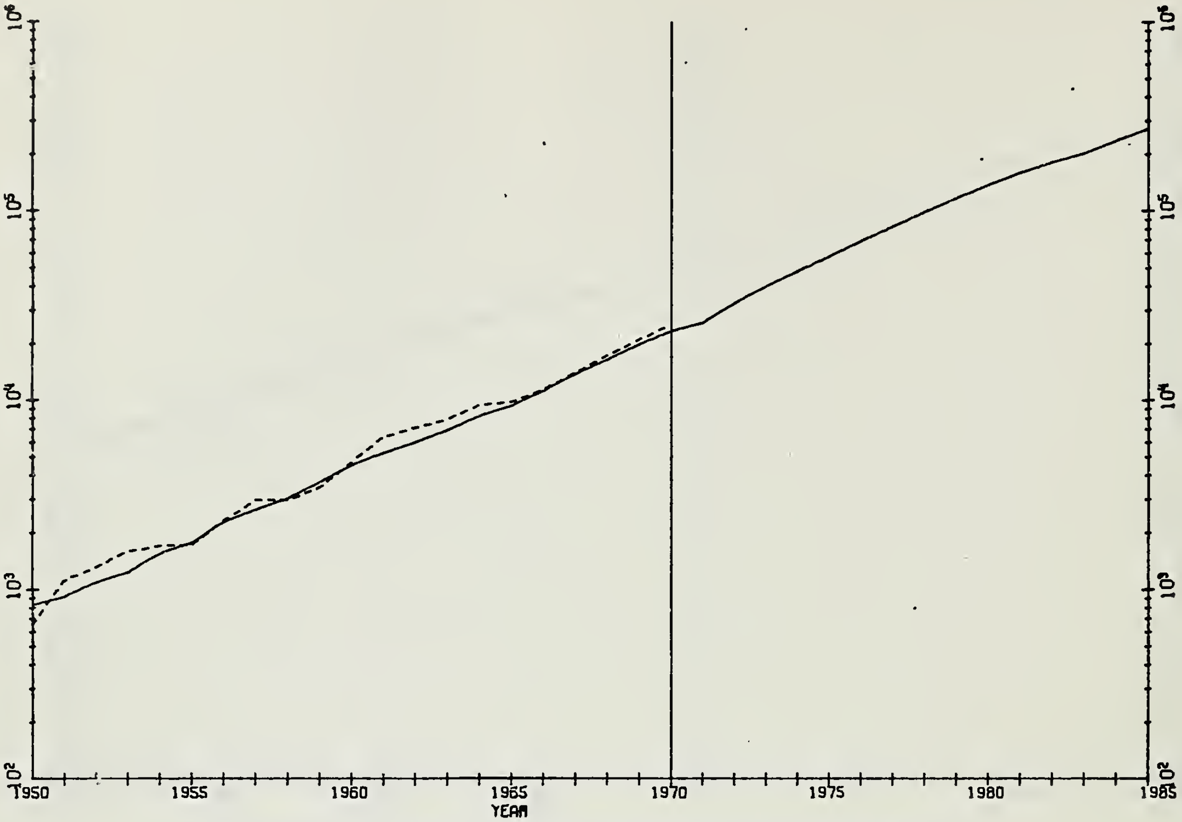

Figure 4-18. Savings (Current Prices) (Billion Yen)

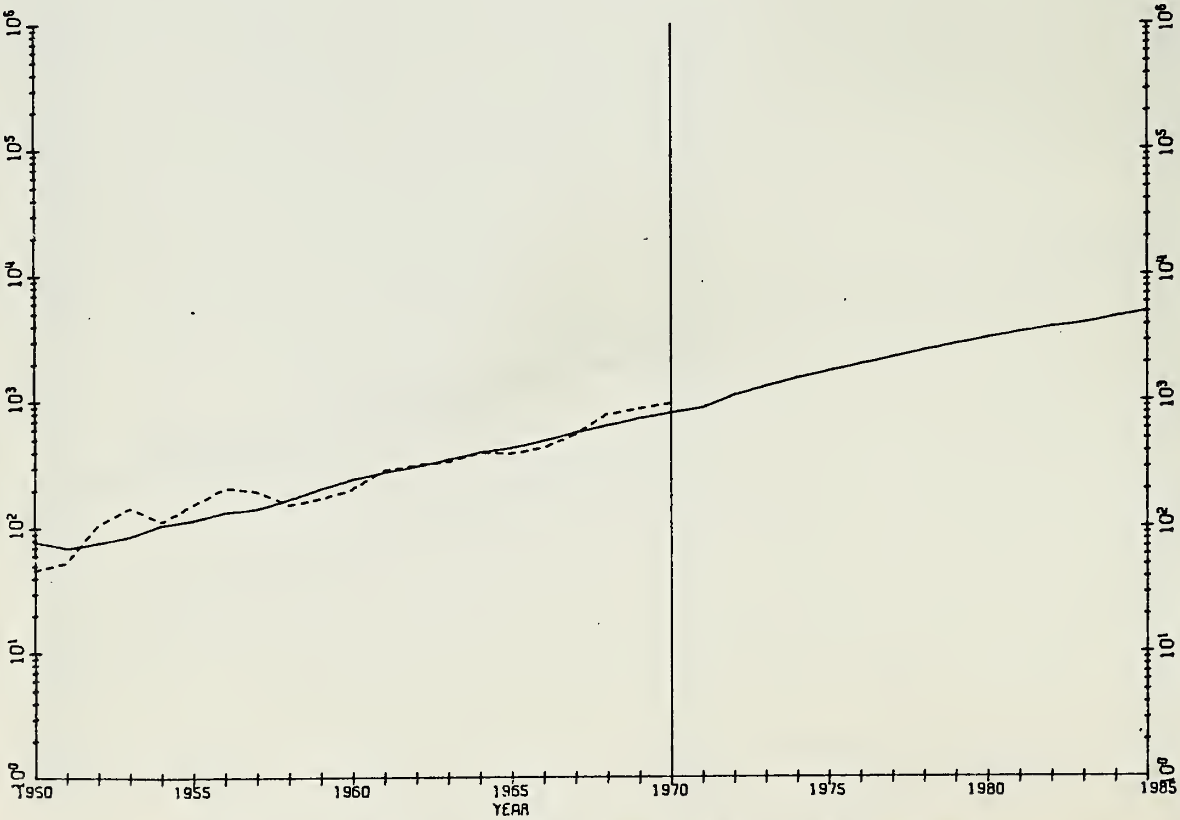

Figure 4-19. Primary Sector Capital Formation (1965 Prices, Billion Yen)

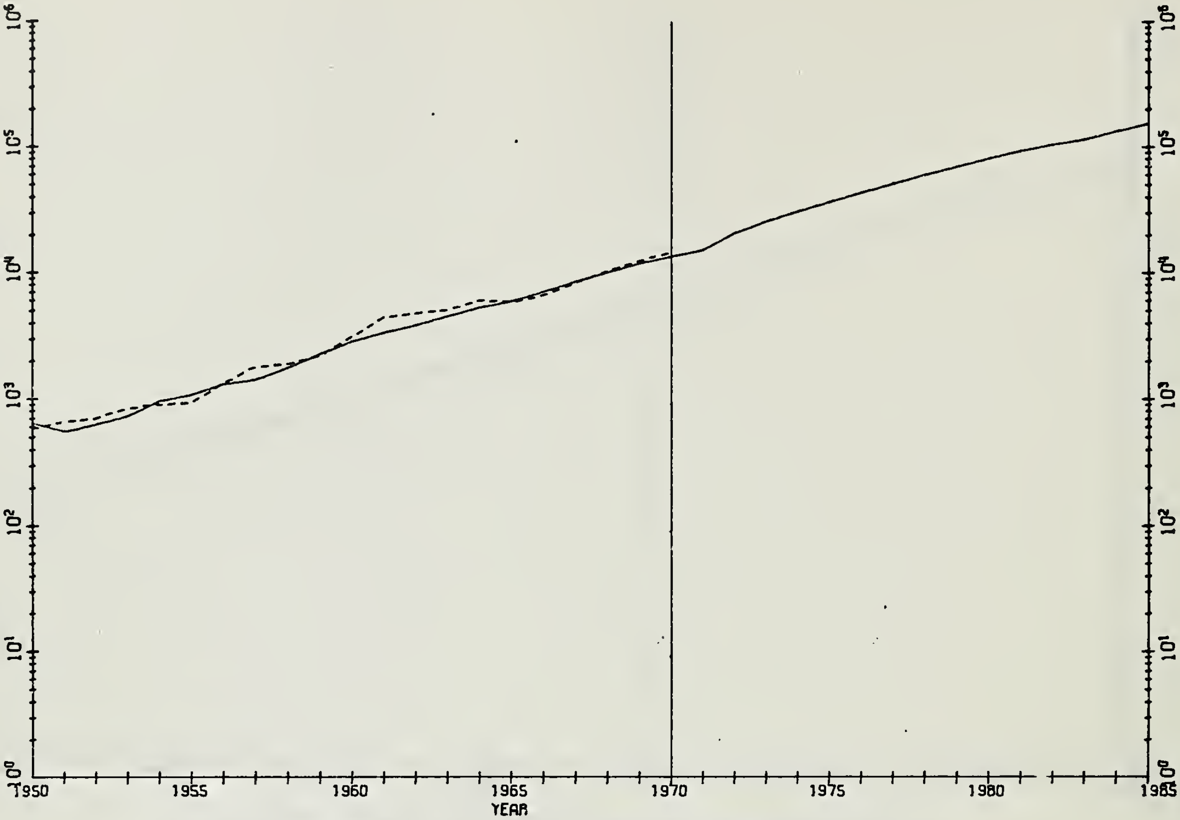

Figure 4-20. Non-Primary Sector Capital Formation (1965 Prices, Billion Yen)

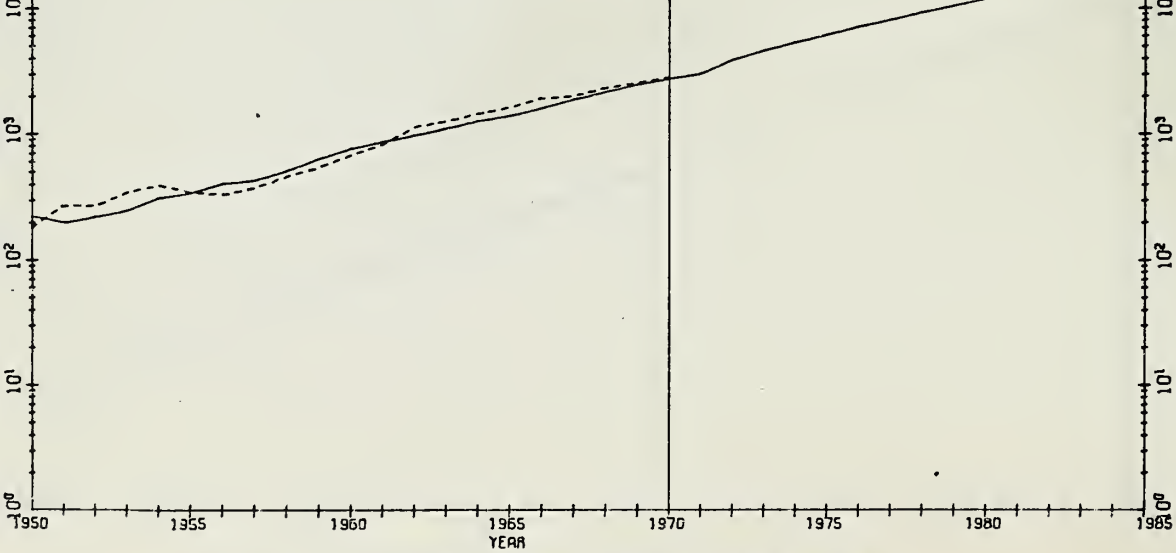

Figure 4-21. Social Capital Formation (1965 Prices, Billion Yen)

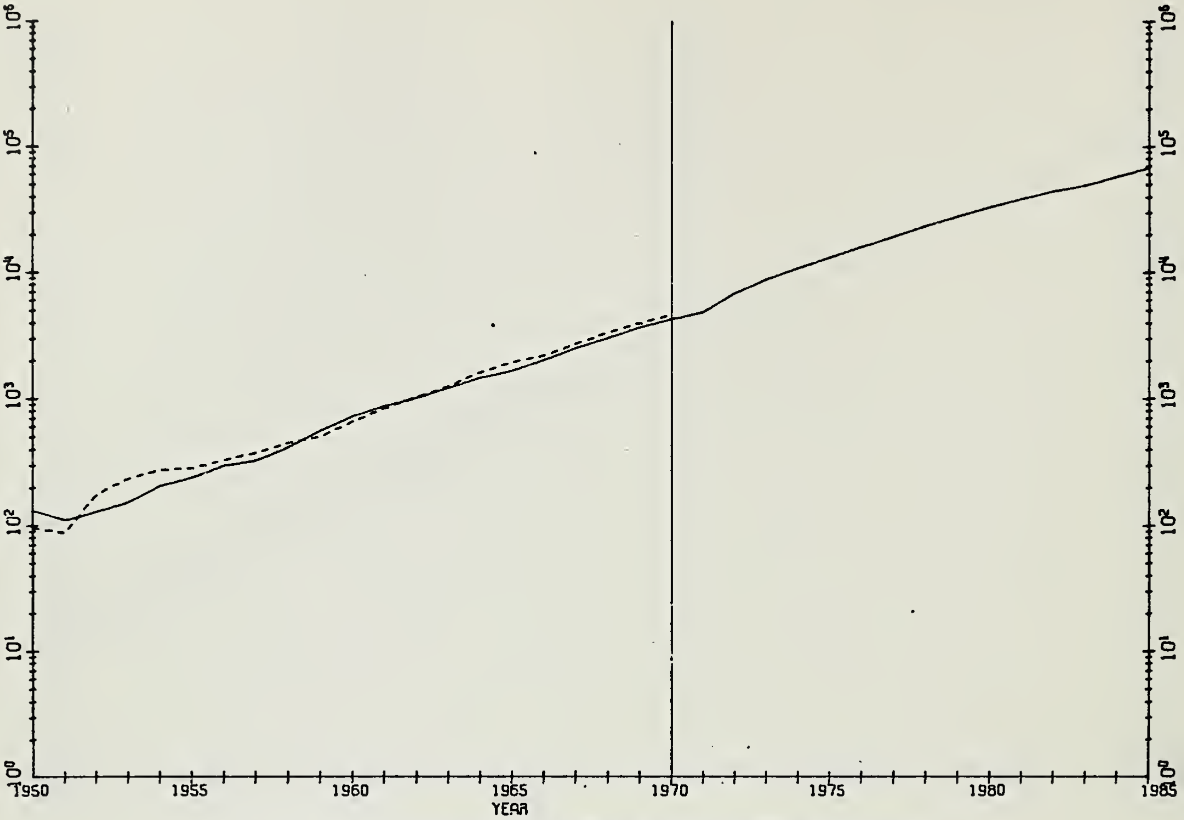

Figure 4-22. Housing Capital Formation (1965 Prices, Billion Yen)

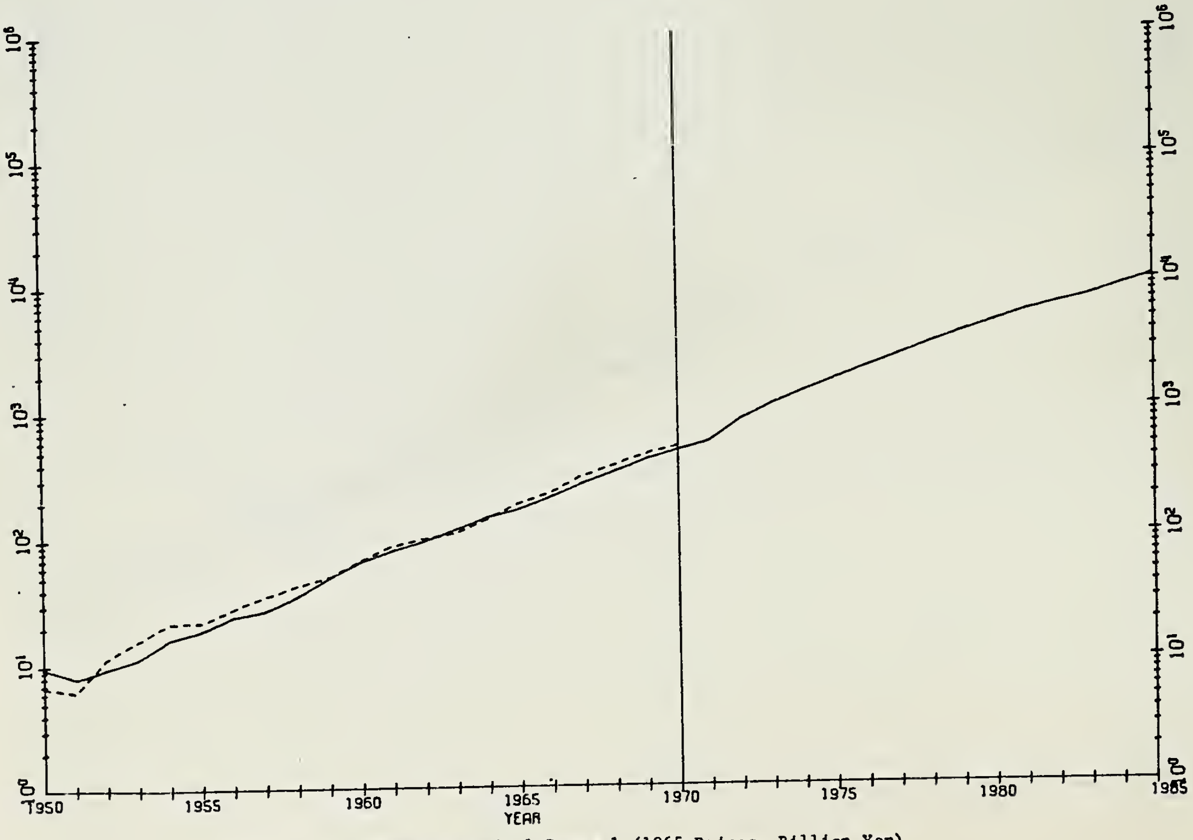

Figure 4-23. Housing Capital Removal (1965 Prices, Billion Yen)

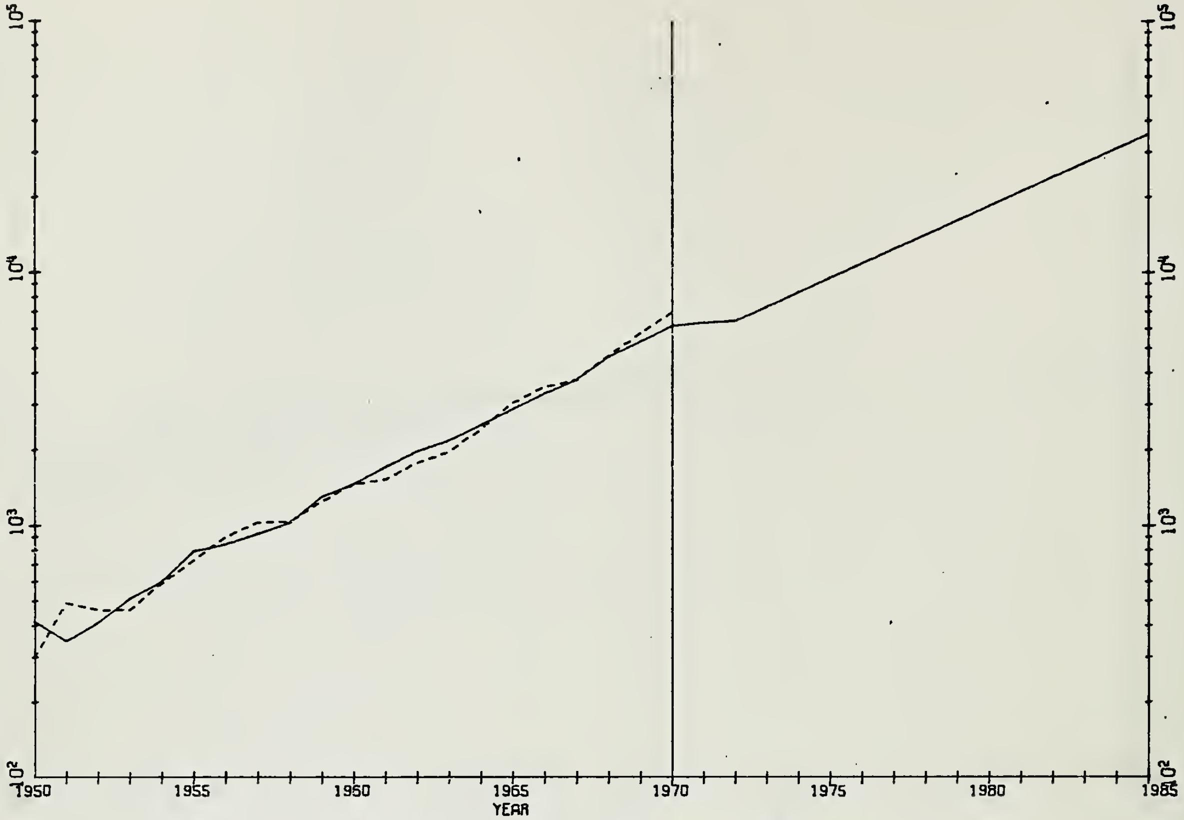

Figure 4-24. Exports (Current Prices, Billion Yen)

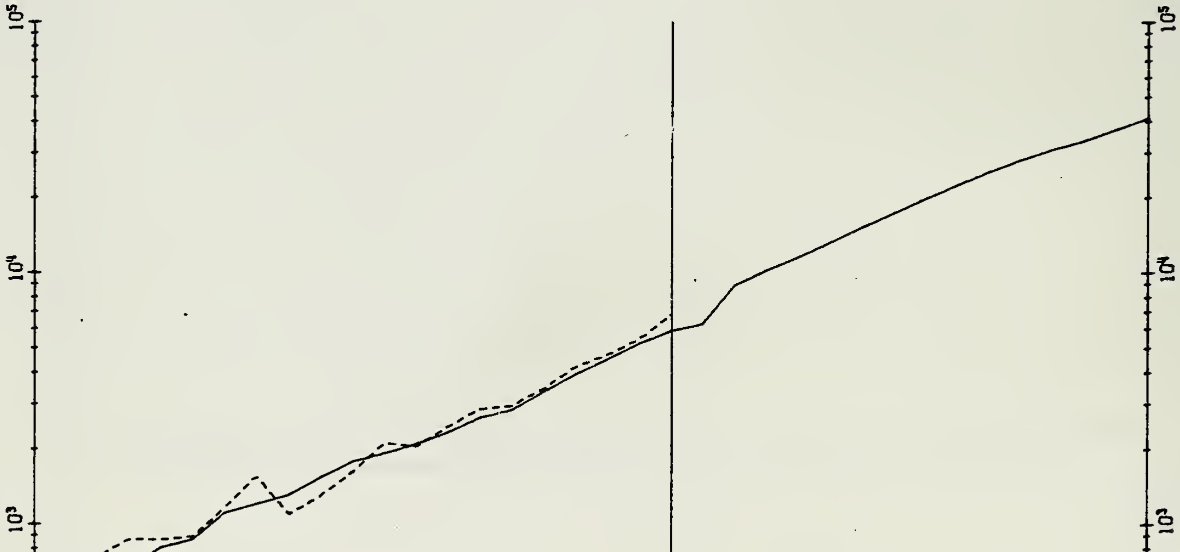

Figure 4-25. Imports (Current Prices, Billion Yen)

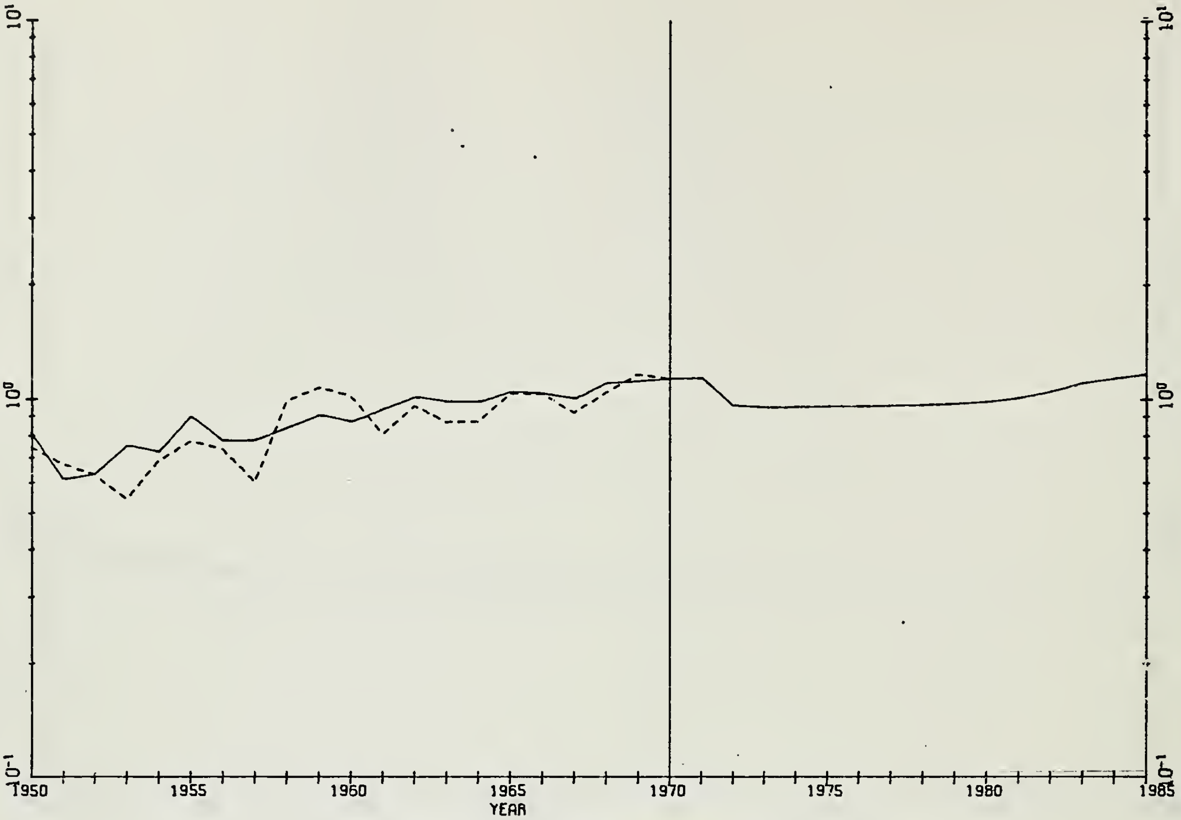

Figure 4-26. Balance of Trade

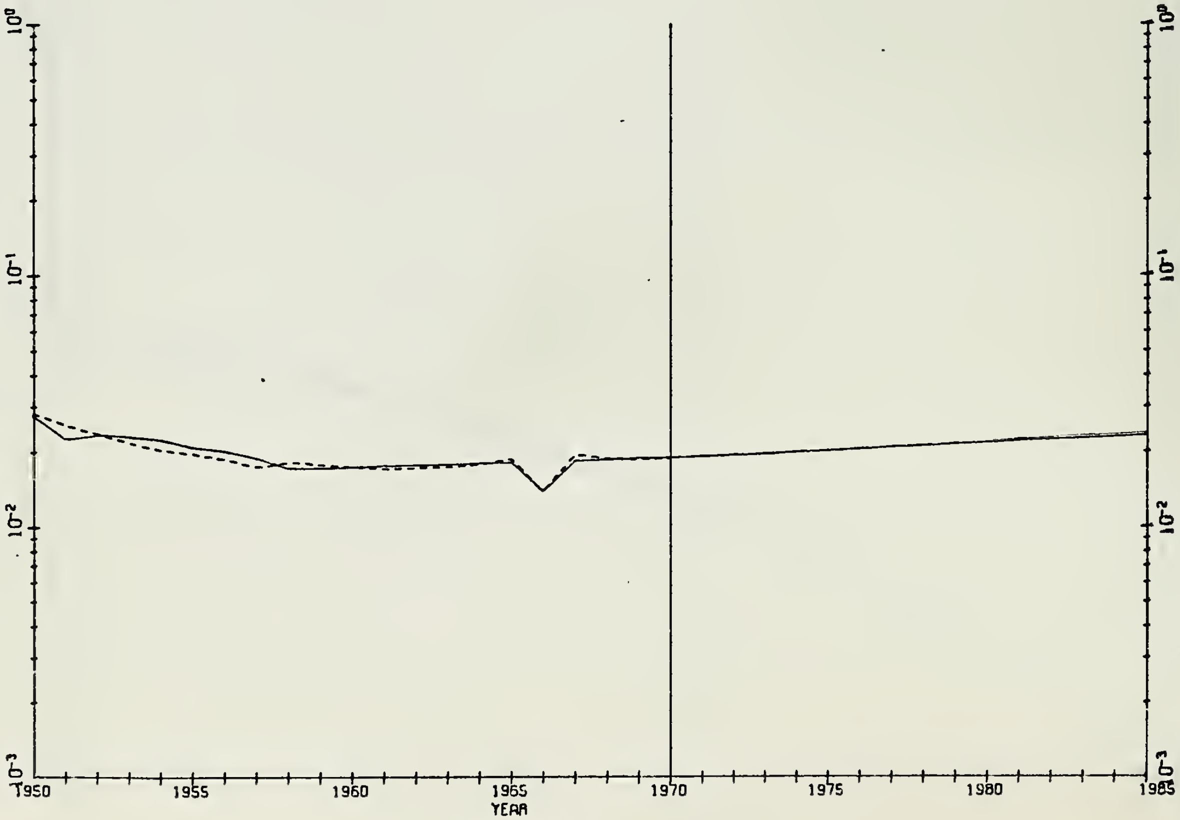

Figure 4-27. Birth Rate

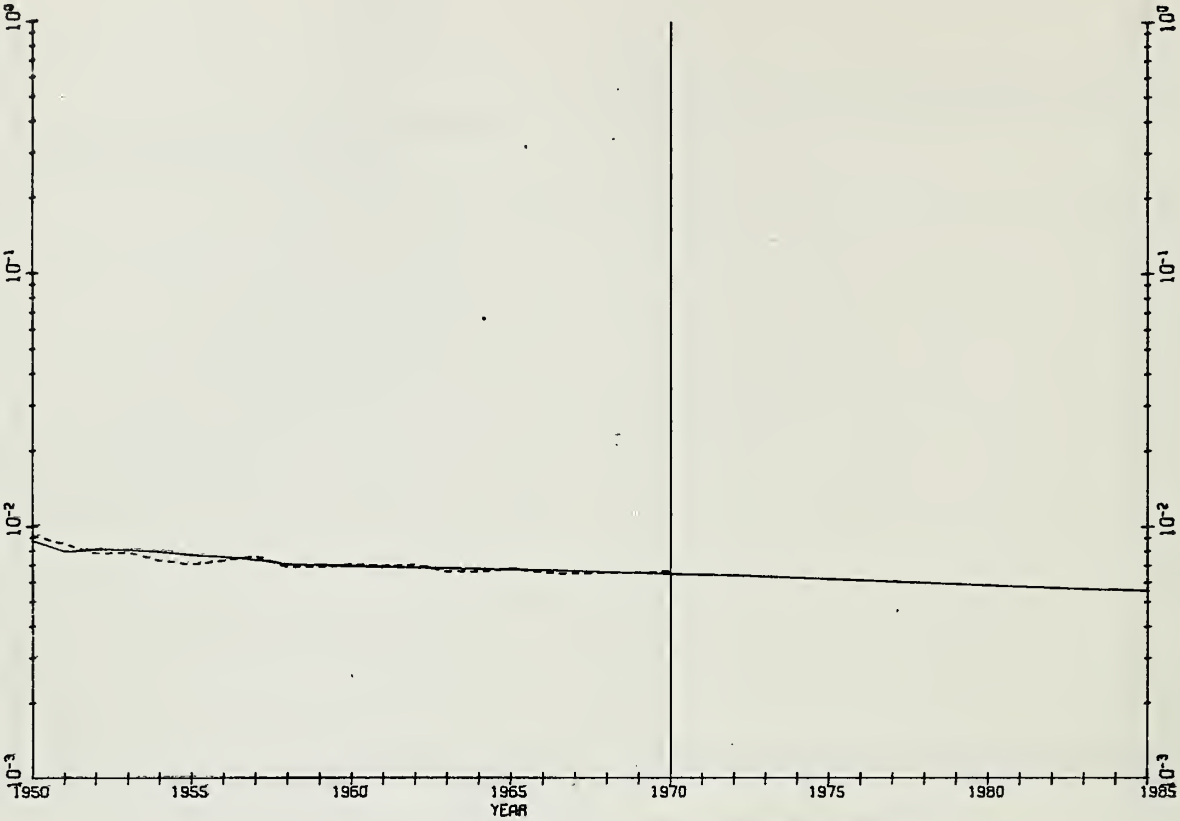

Figure 4-28. Death Rate (Other Than Infants)

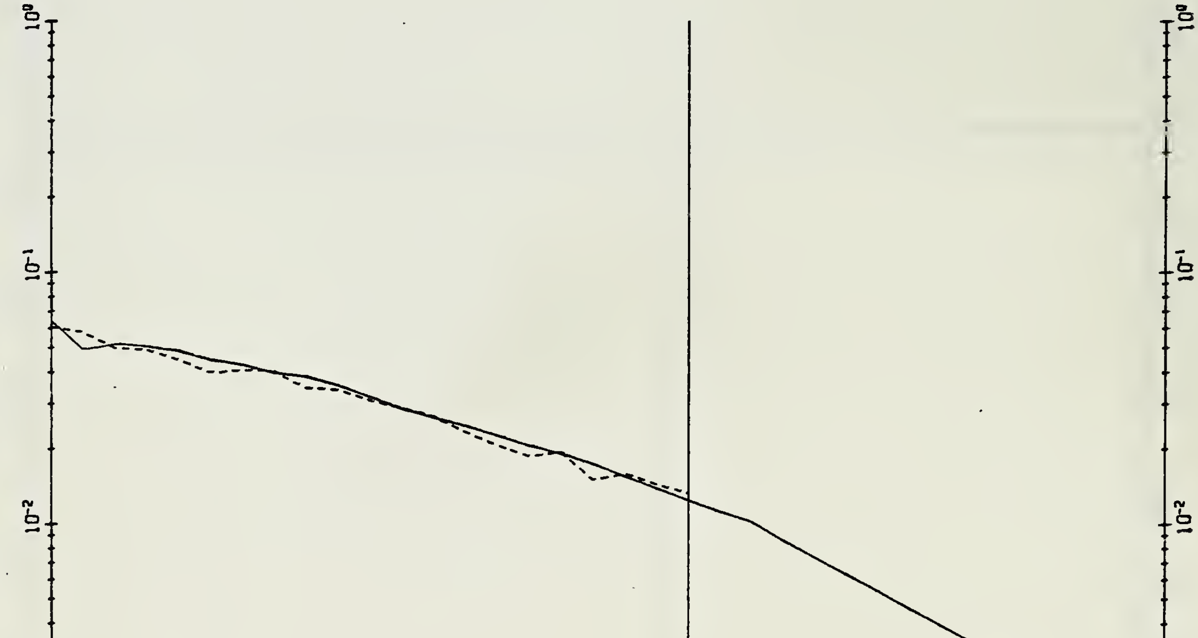

Figure 4-29. Infant Death Rate

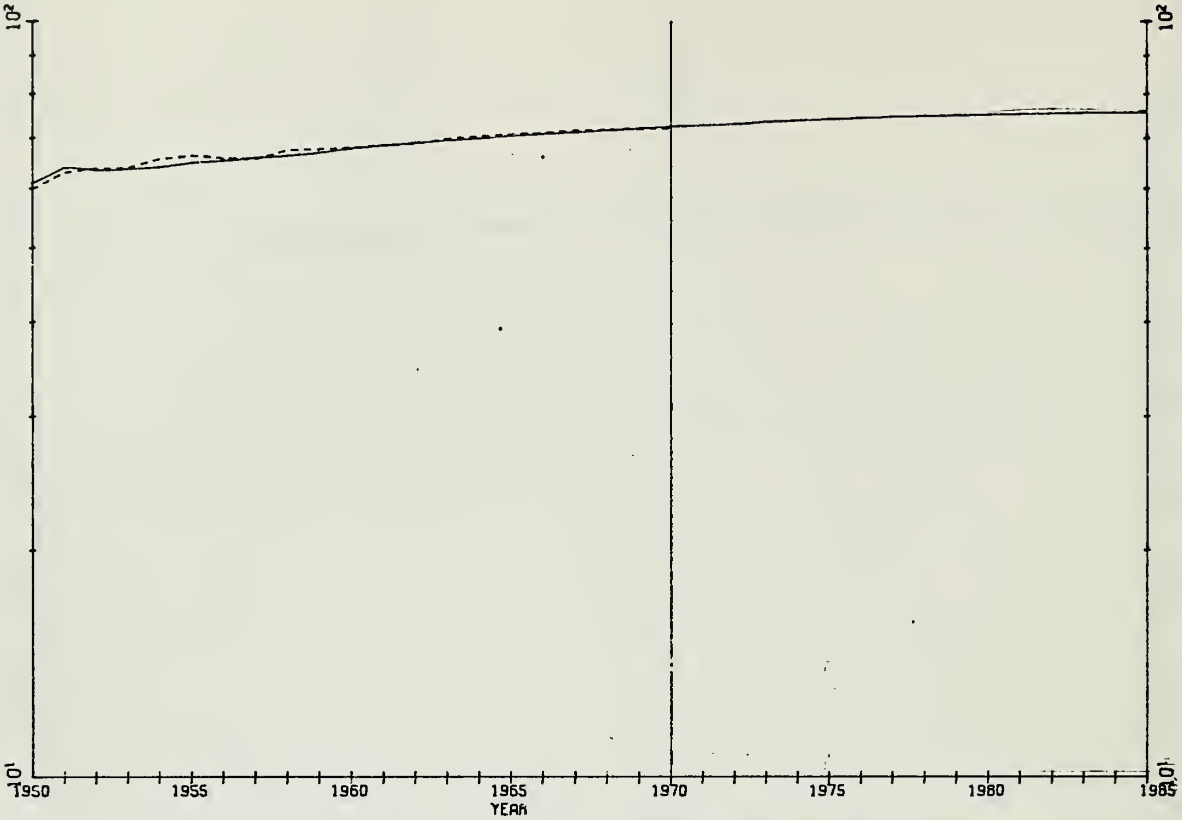

Figure 4-30. Life Expectancy, Average of Male and Female (Years)

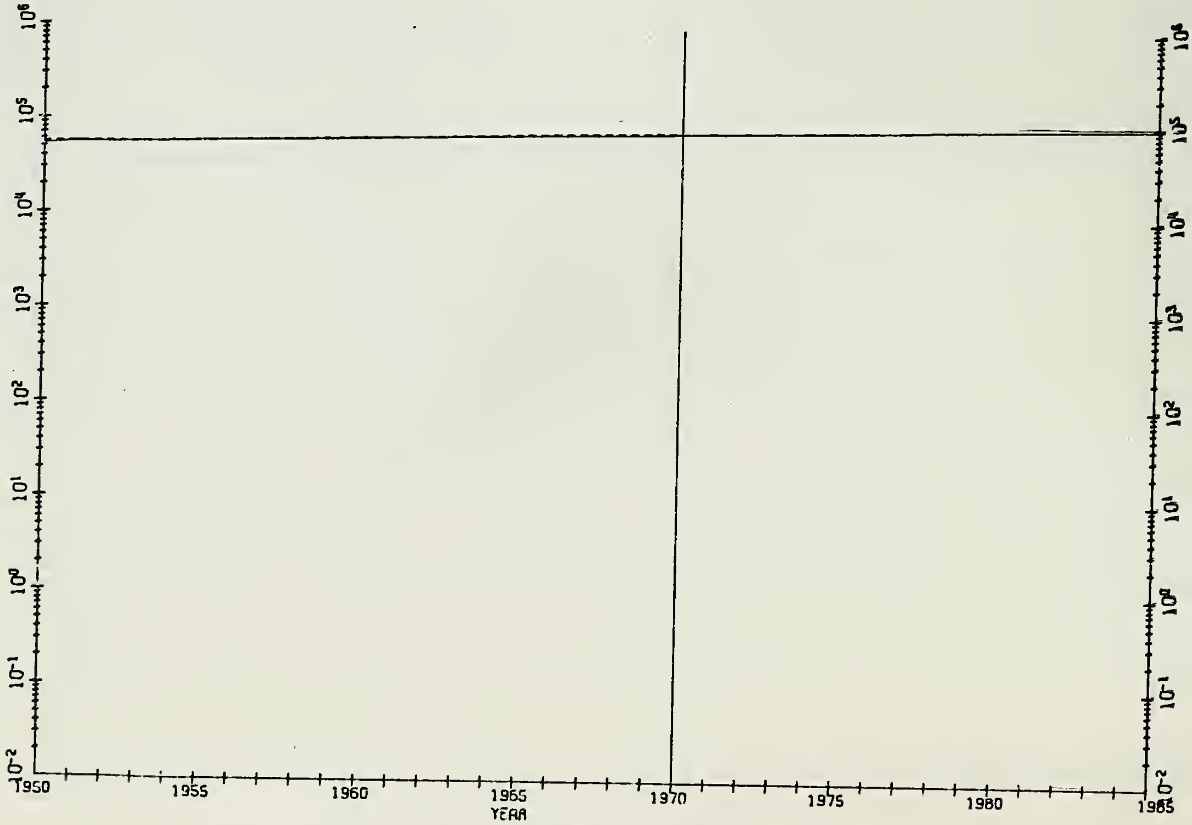

Figure 4-31. Population 15 Years of Age and Older (Thousands)

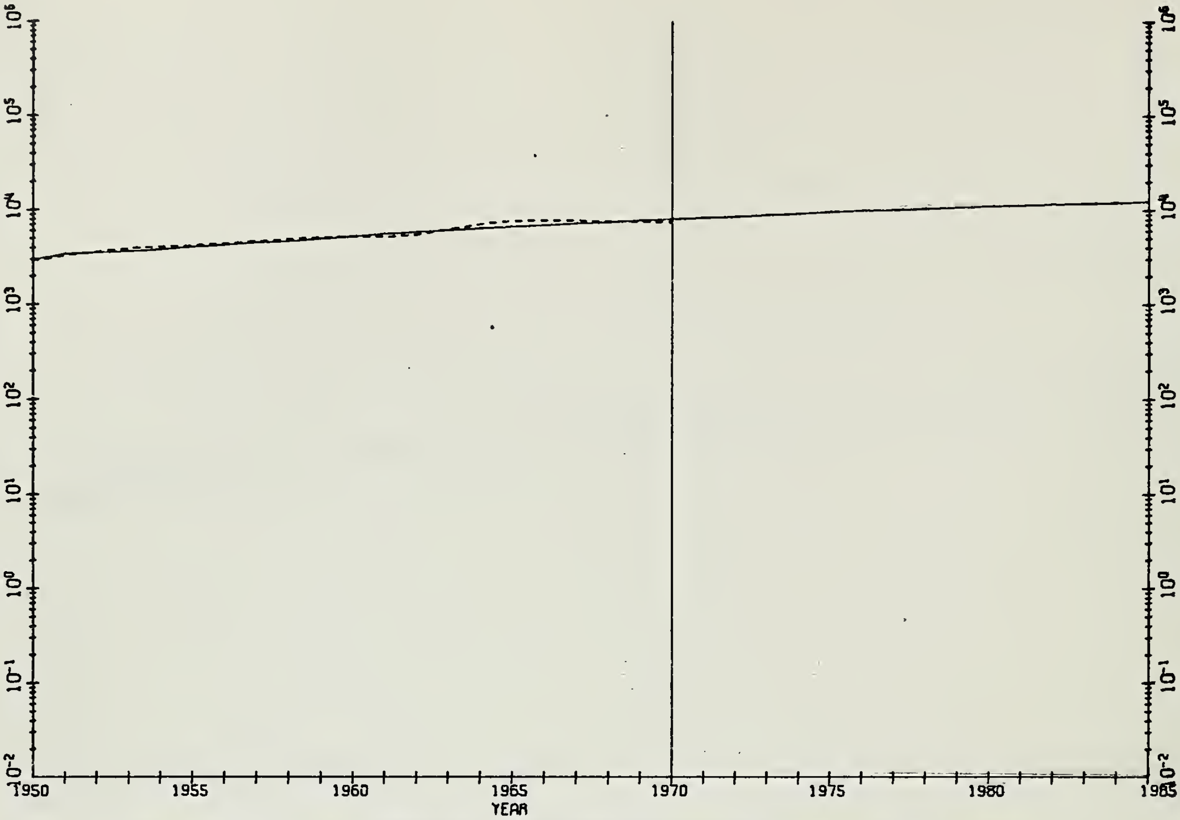

Figure 4-32. 15 Years of Age and Older Attending Educational Institutions (Thousands)

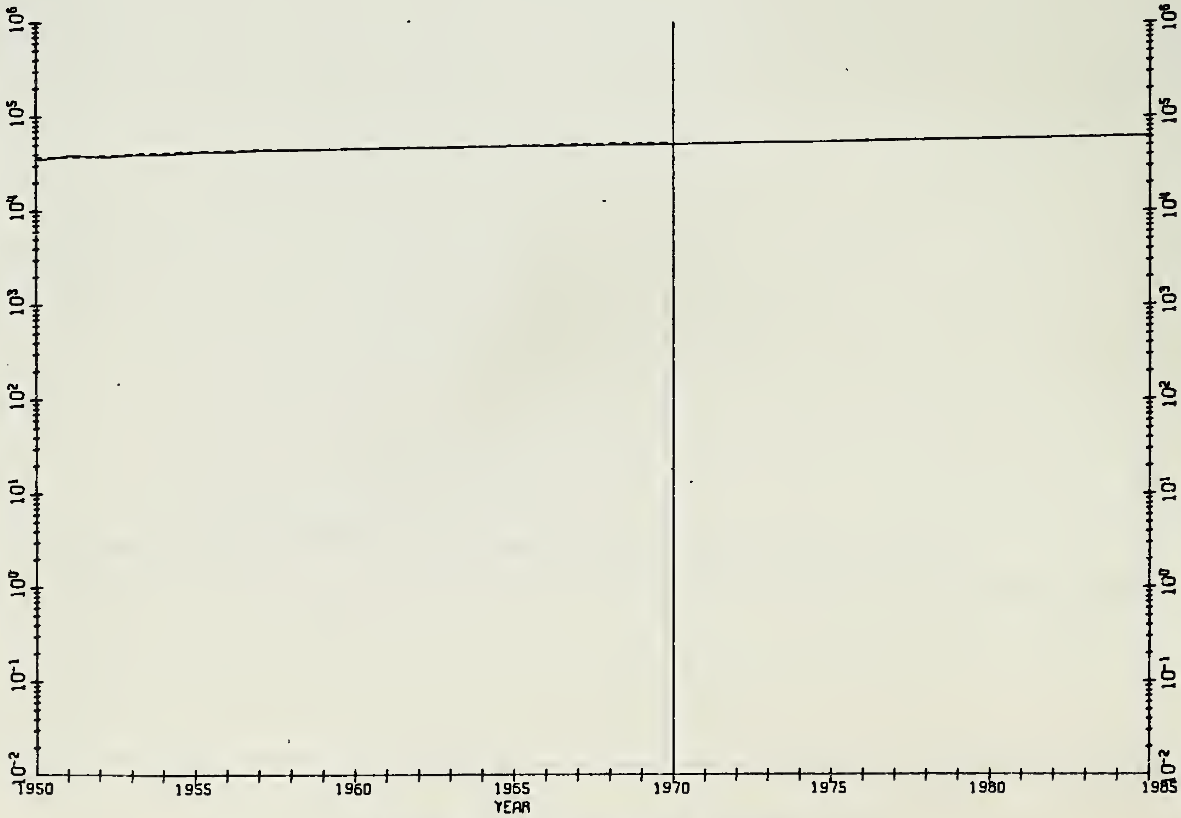

Figure 4-33. Total Labor Force (Thousands)

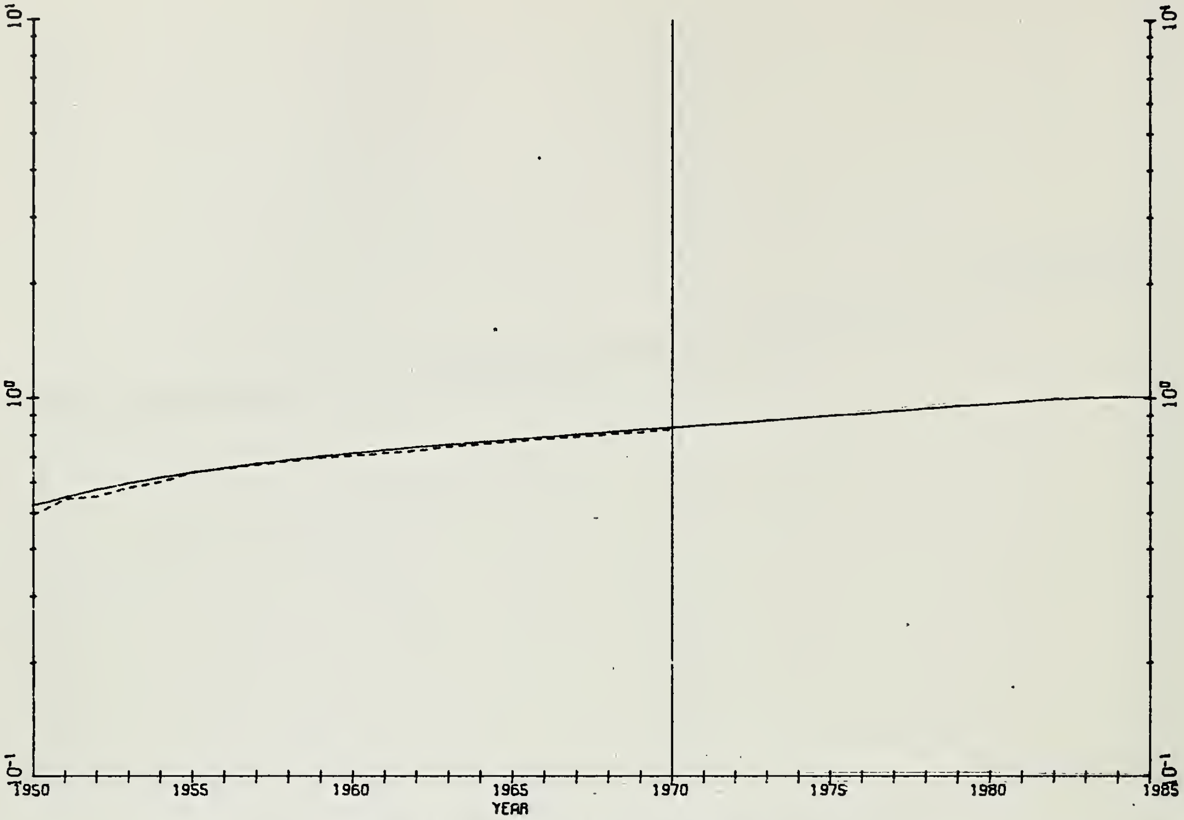

Figure 4-34. Labor Force Allocation

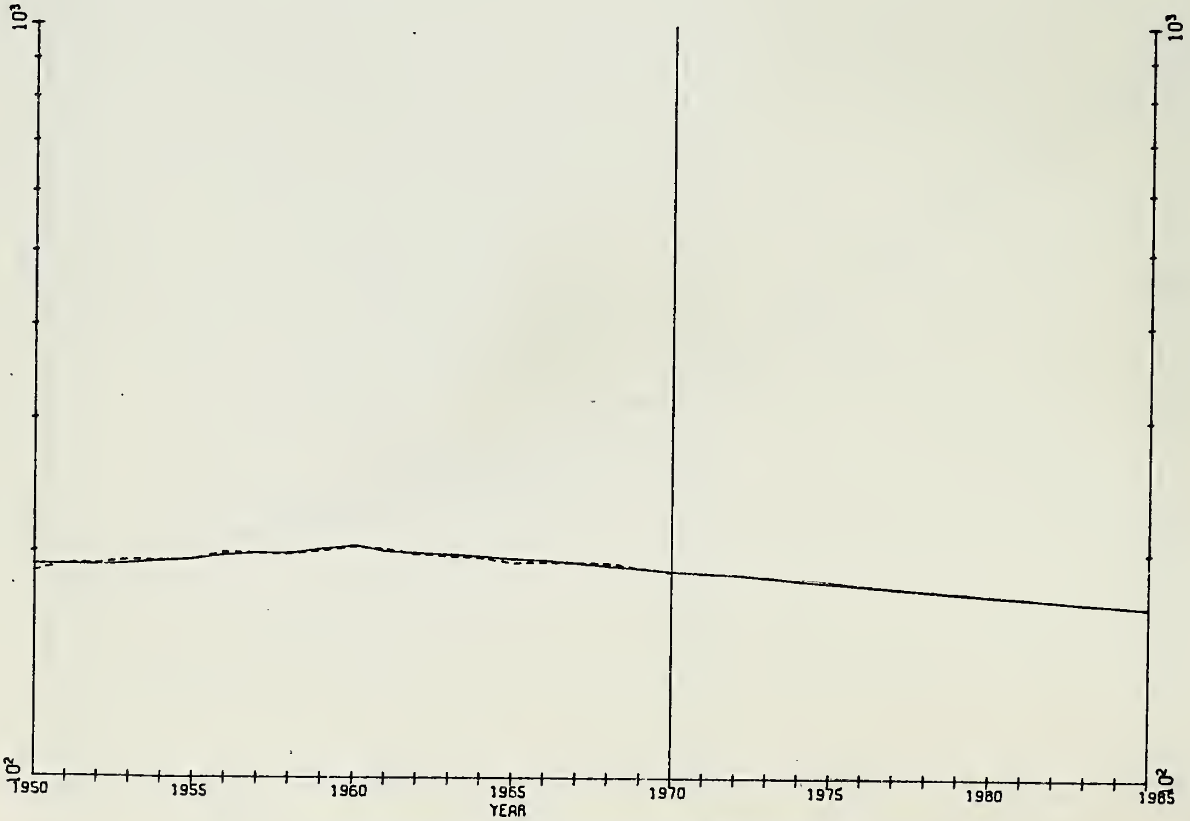

Figure 4-35. Monthly Work Hours in Non-Primary Sector

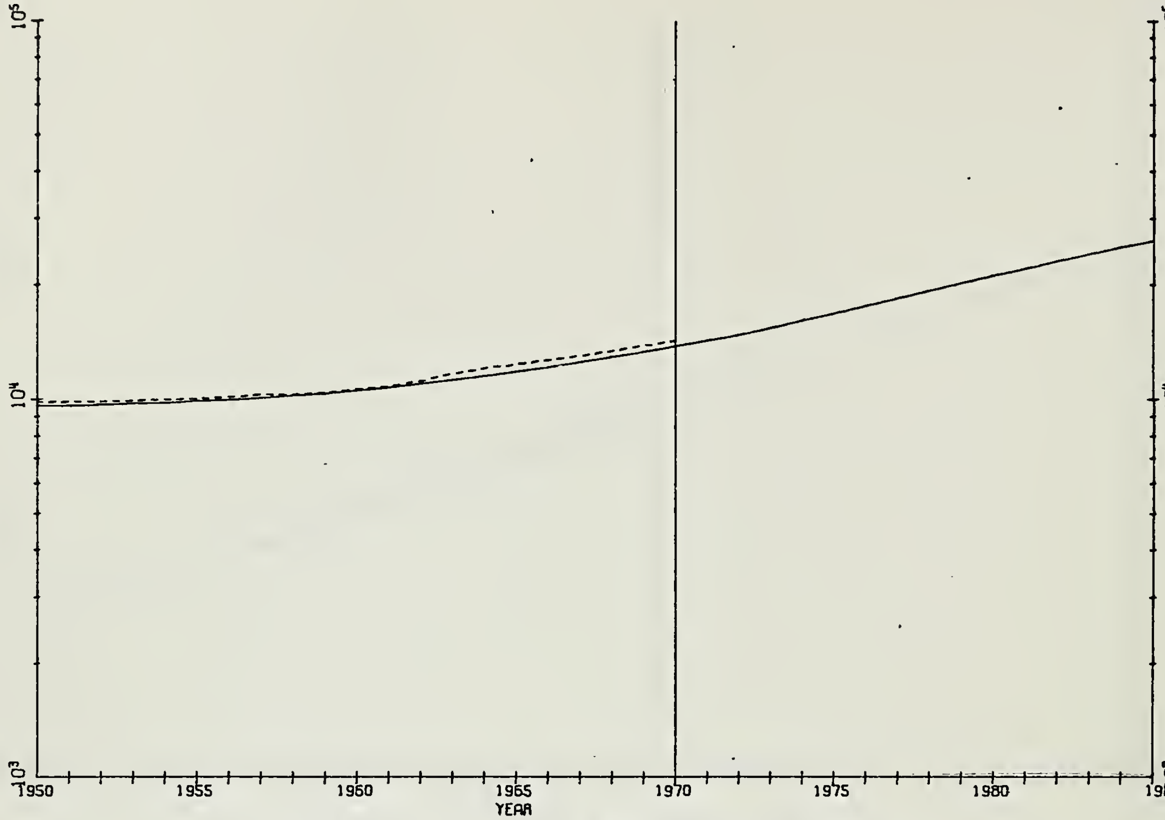

Figure 4-36. Land Used (Other Than Primary) (Square Kilometer)

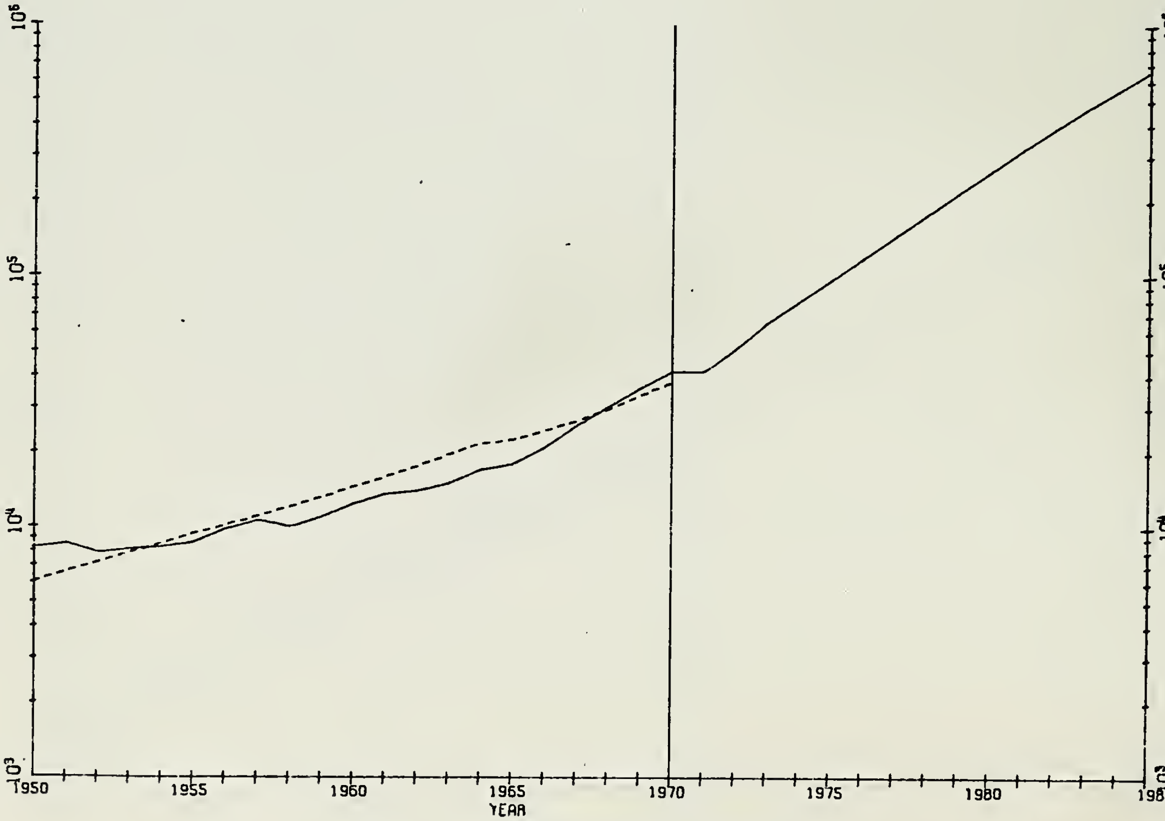

Figure 4-37. Input of Water = Output of Polluted Water (Million Cubic Meters/Year)

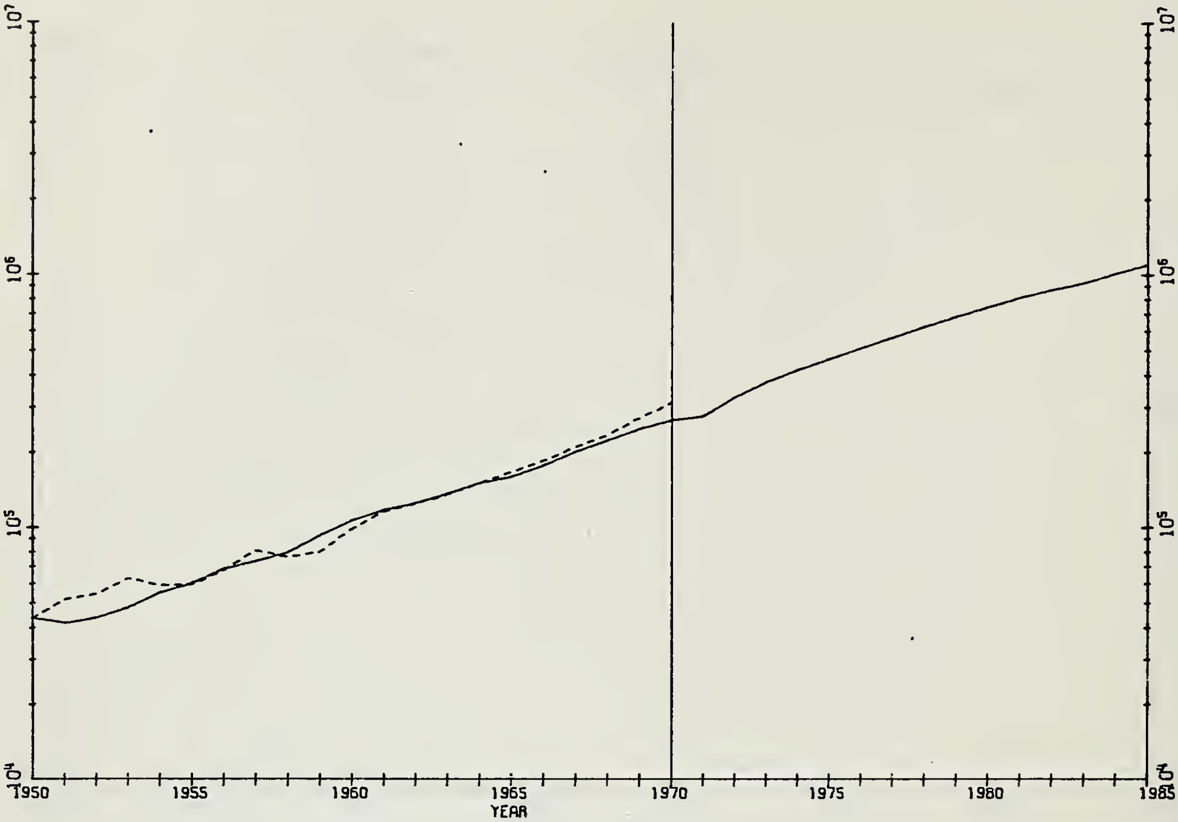

Figure 4-38. Output of Air Pollutant (1000 Tons/Year)

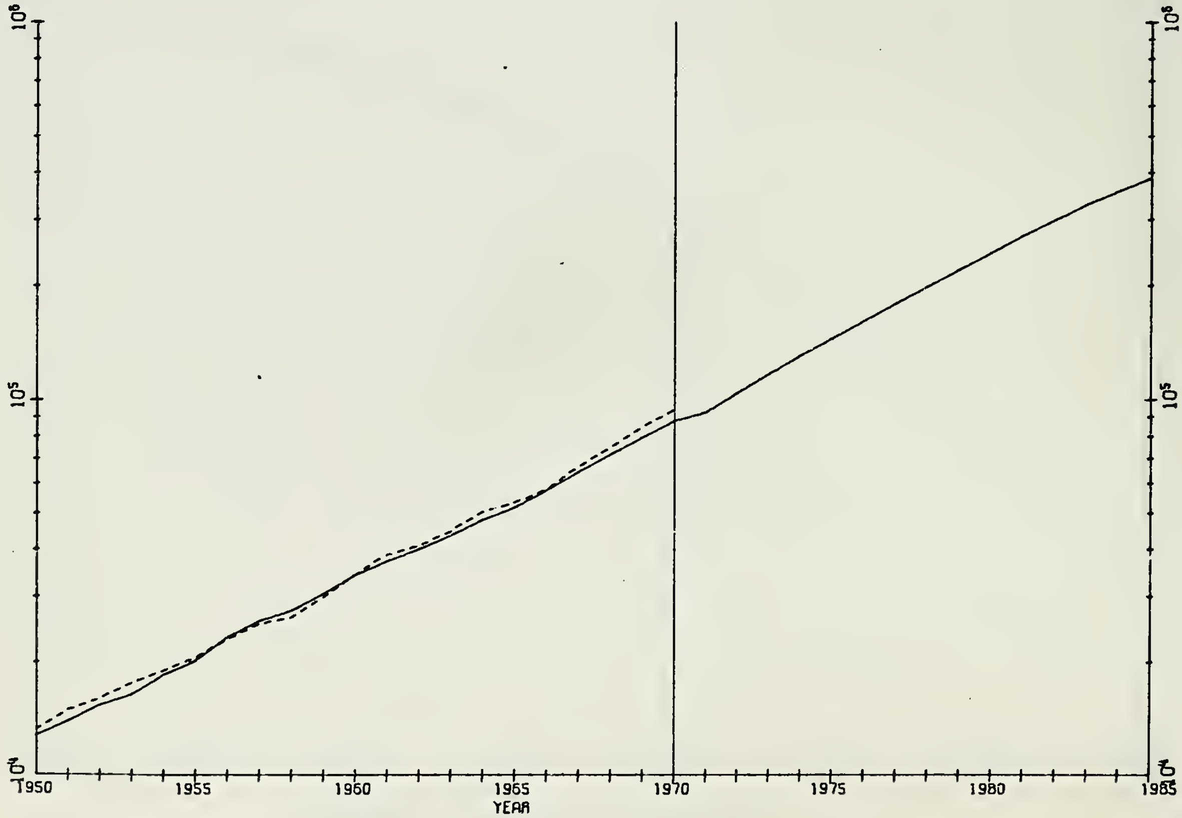

Figure 4-39. Output of Waste (1000 Tons/Year)

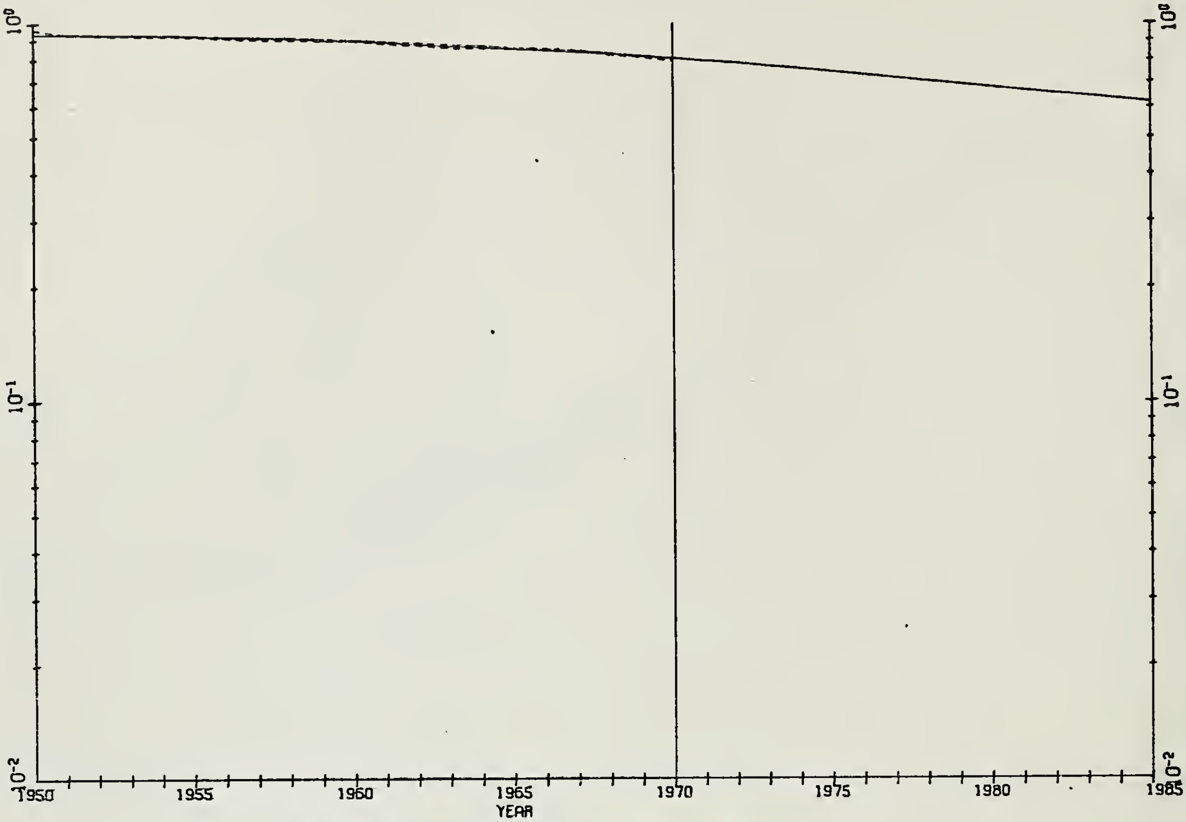

Figure 4-40. Water Pollutant Removal Rate (1-Water)

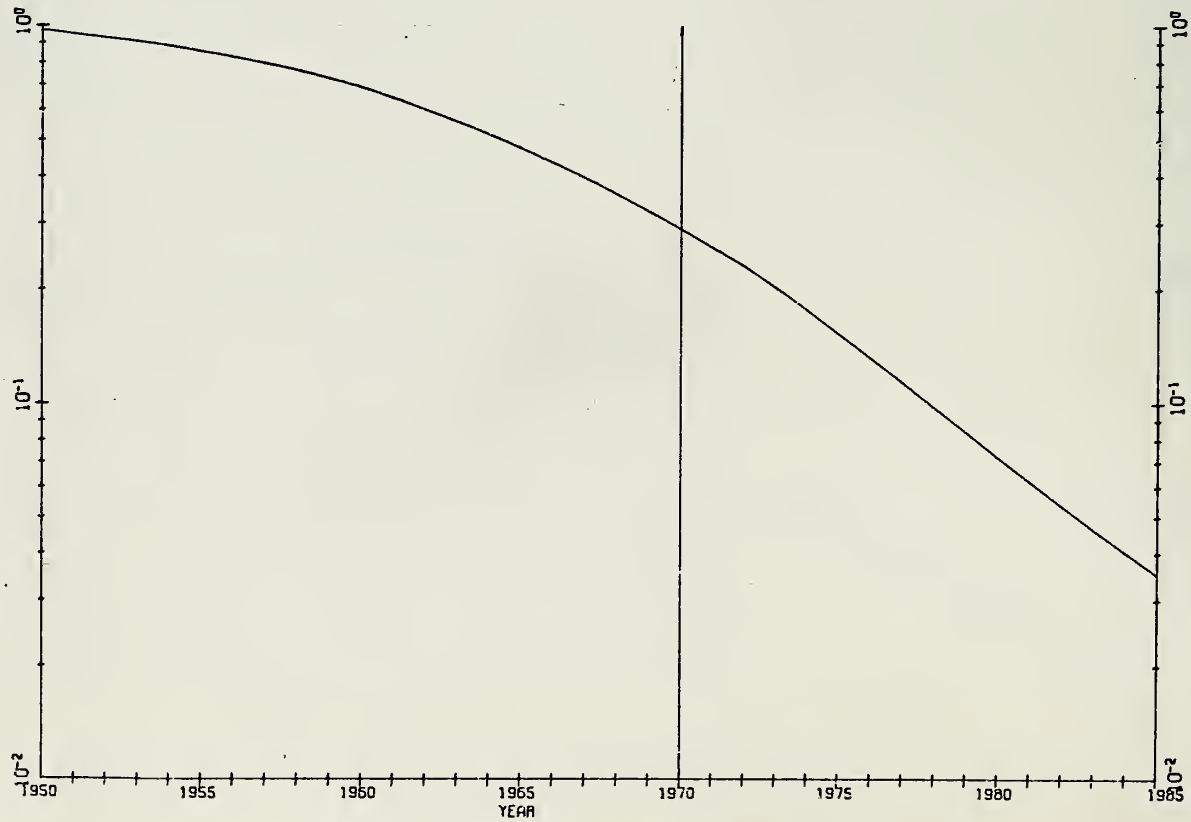

Figure 4-41. Waste Collection Rate (1-Zwaste)

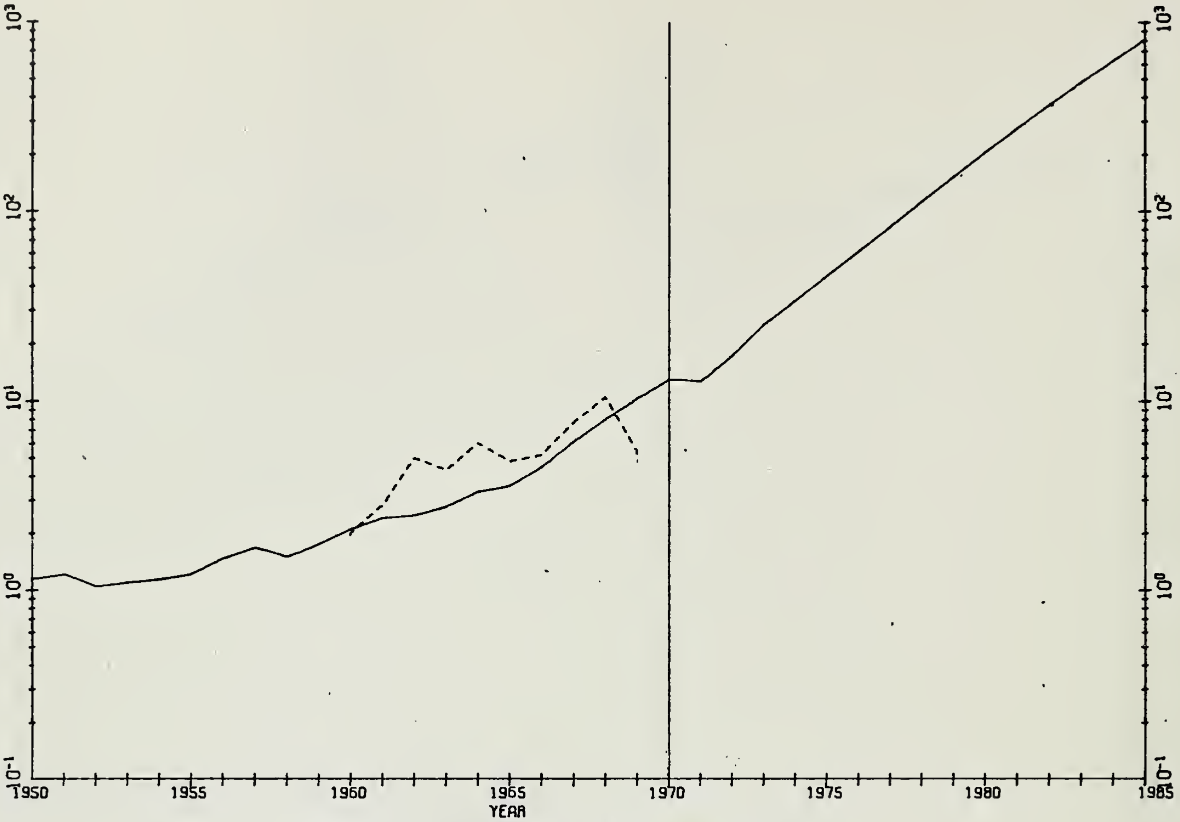

Figure 4-42. Water Pollution Level, BOD (PPM)

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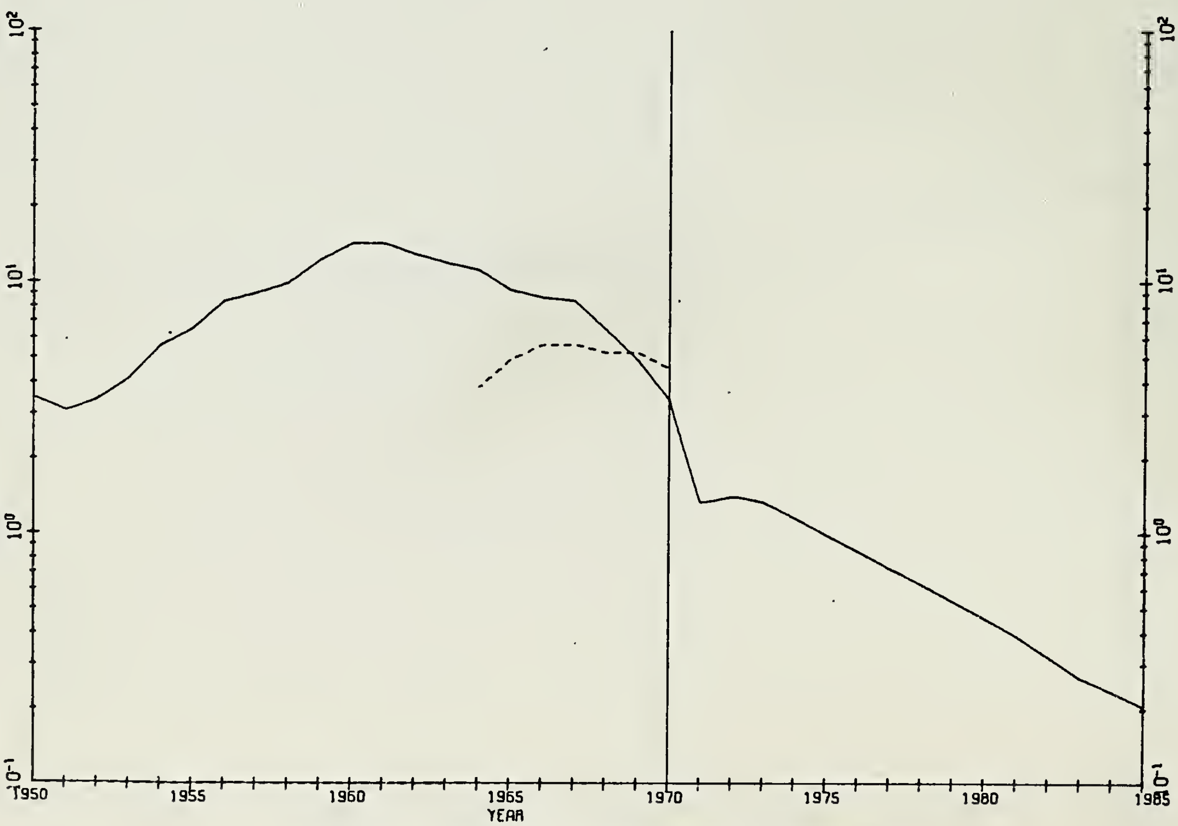

Figure 4-43. Air Pollution Level, Sulphur Dioxide (PPM)

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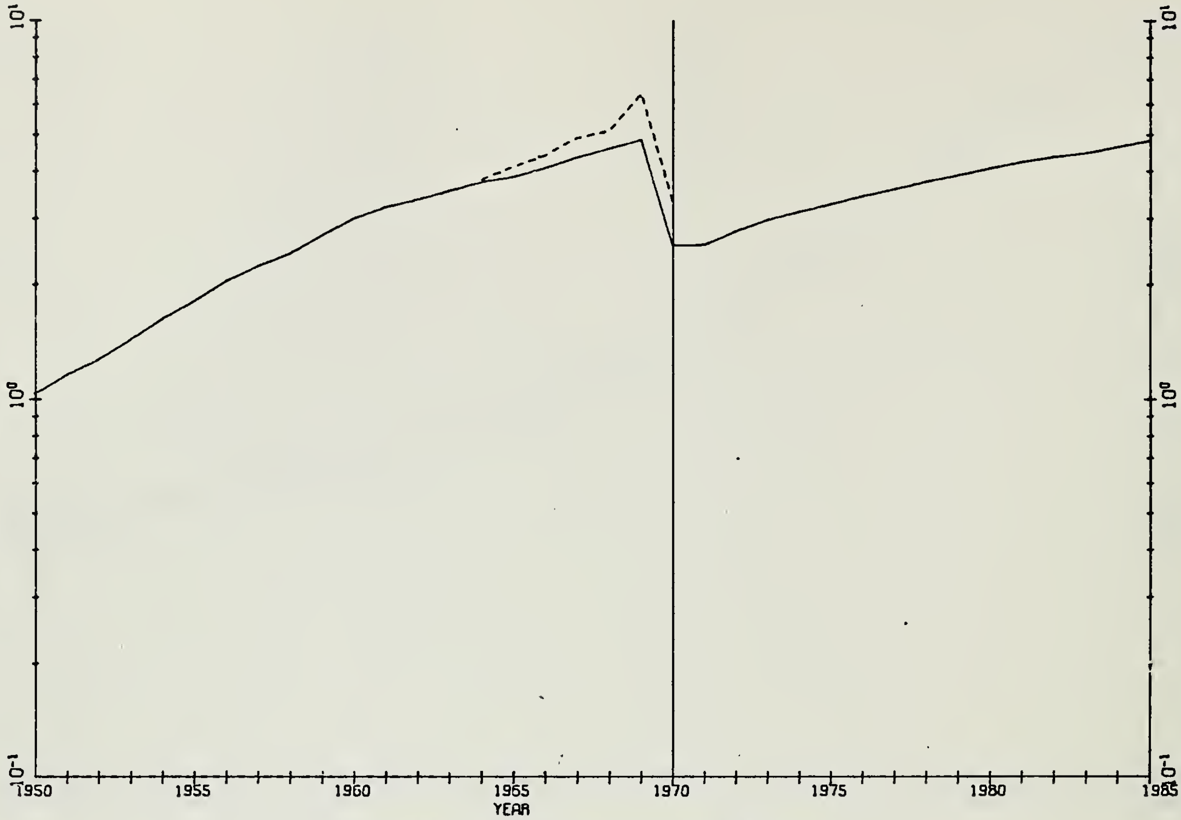

Figure 4-44. Air Pollution Level, CO (PPM)

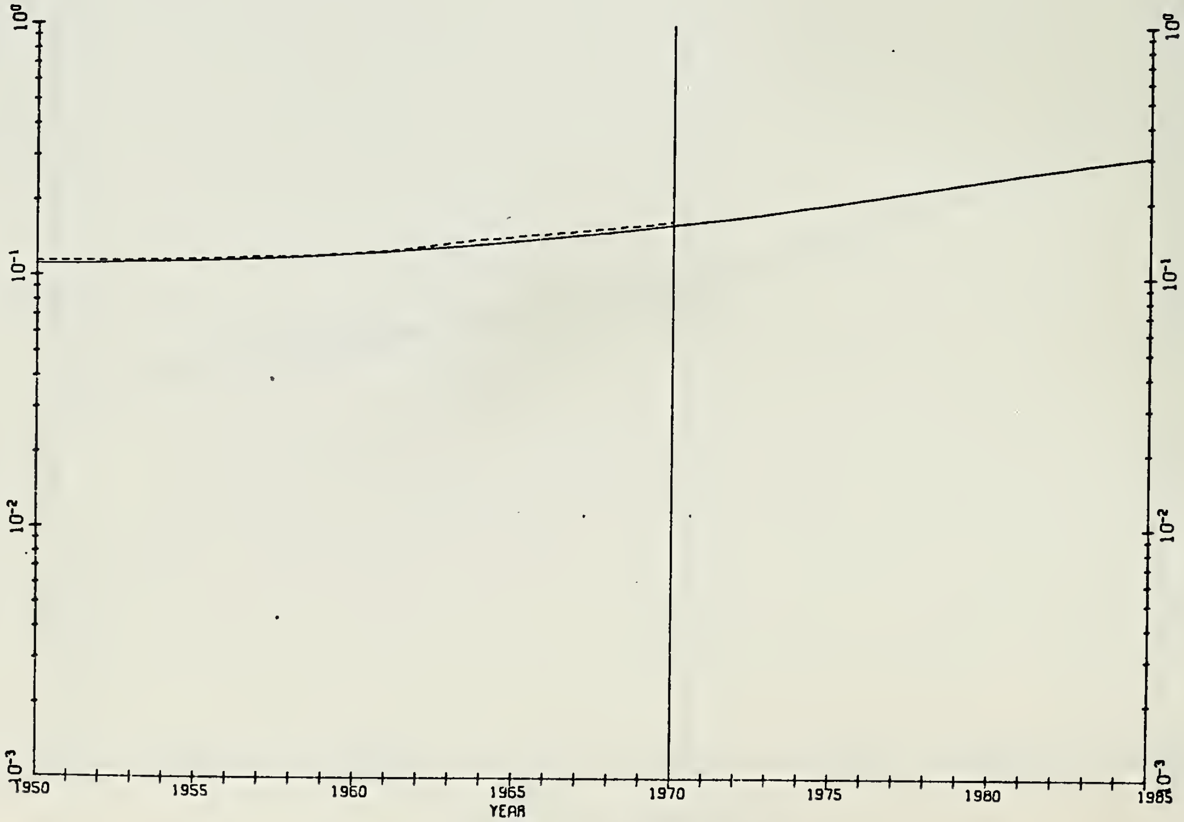

Figure 4-45. Rate of Land Utilization

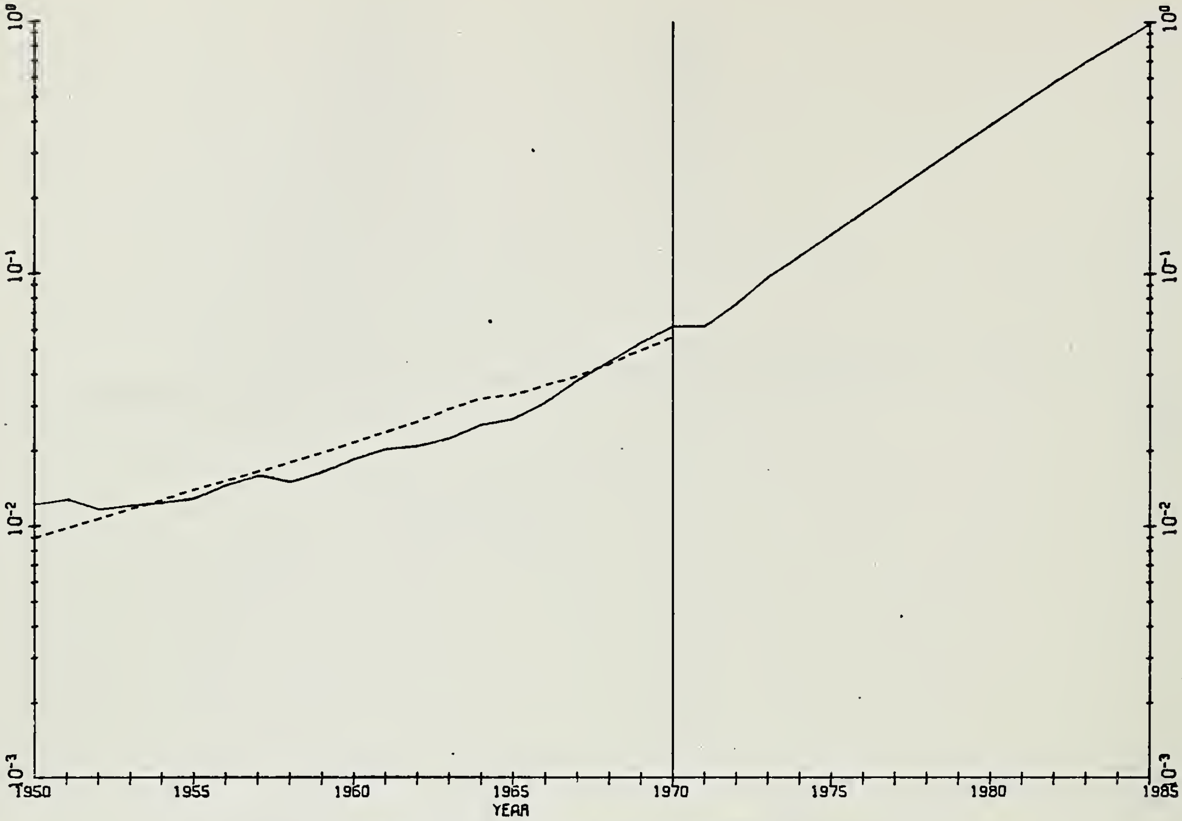

Figure 4-46. Rate of Water Utilization

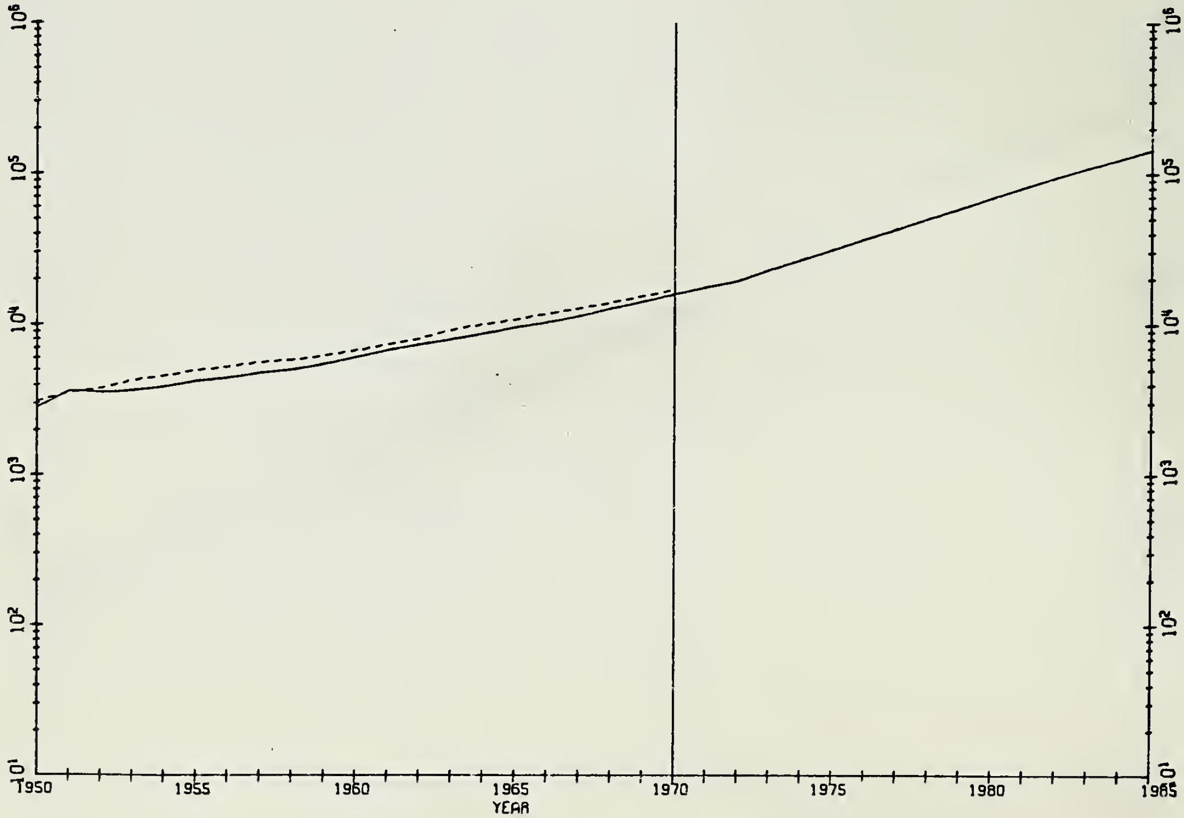

Figure 4-47. Material Benefit

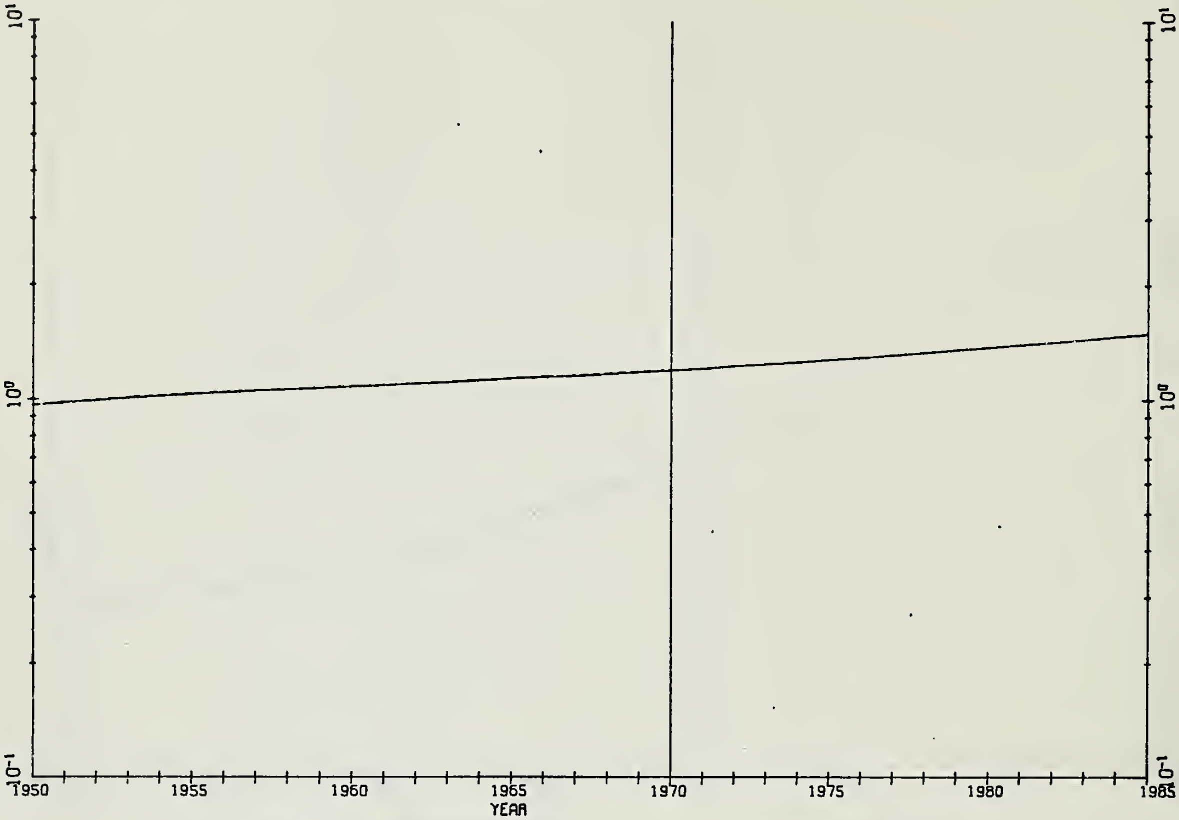

Figure 4-48. Population Density (Thousand People/Square km)

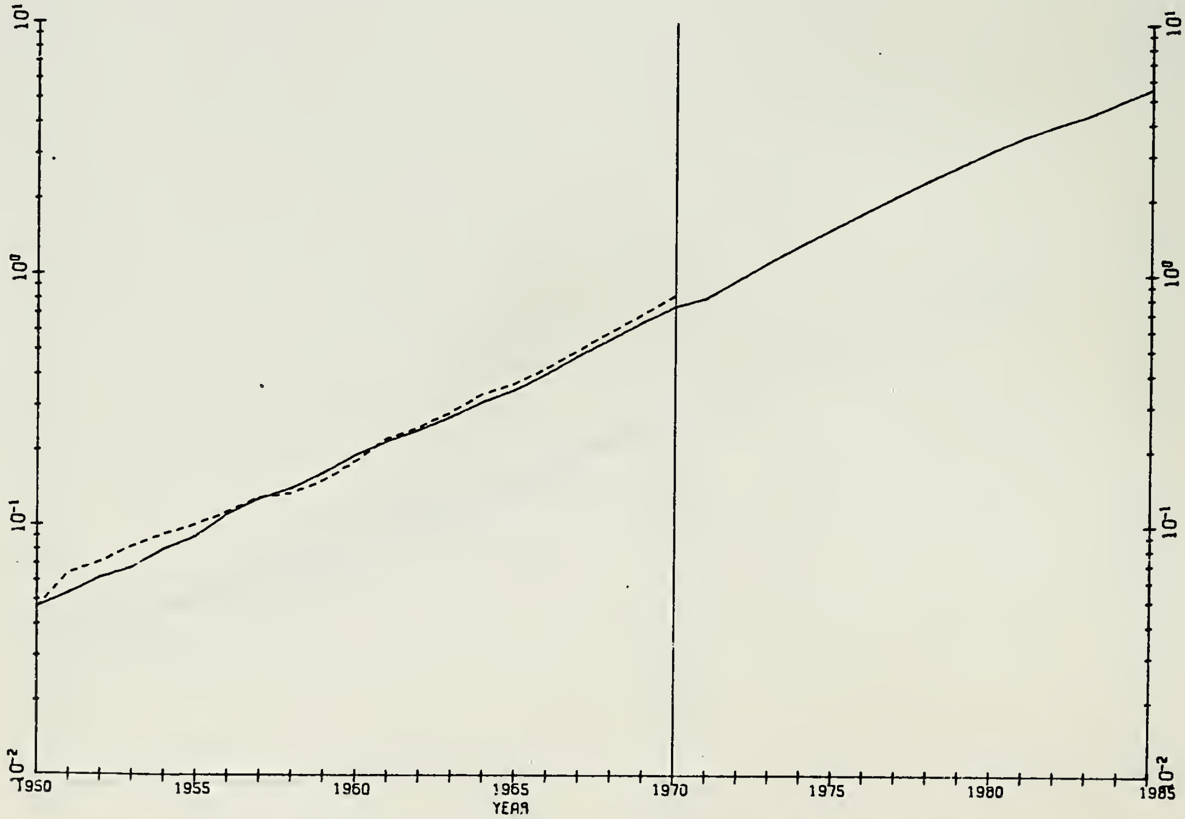

Figure 4-49. Production Density (Value Added in Billion Yen/Square km)

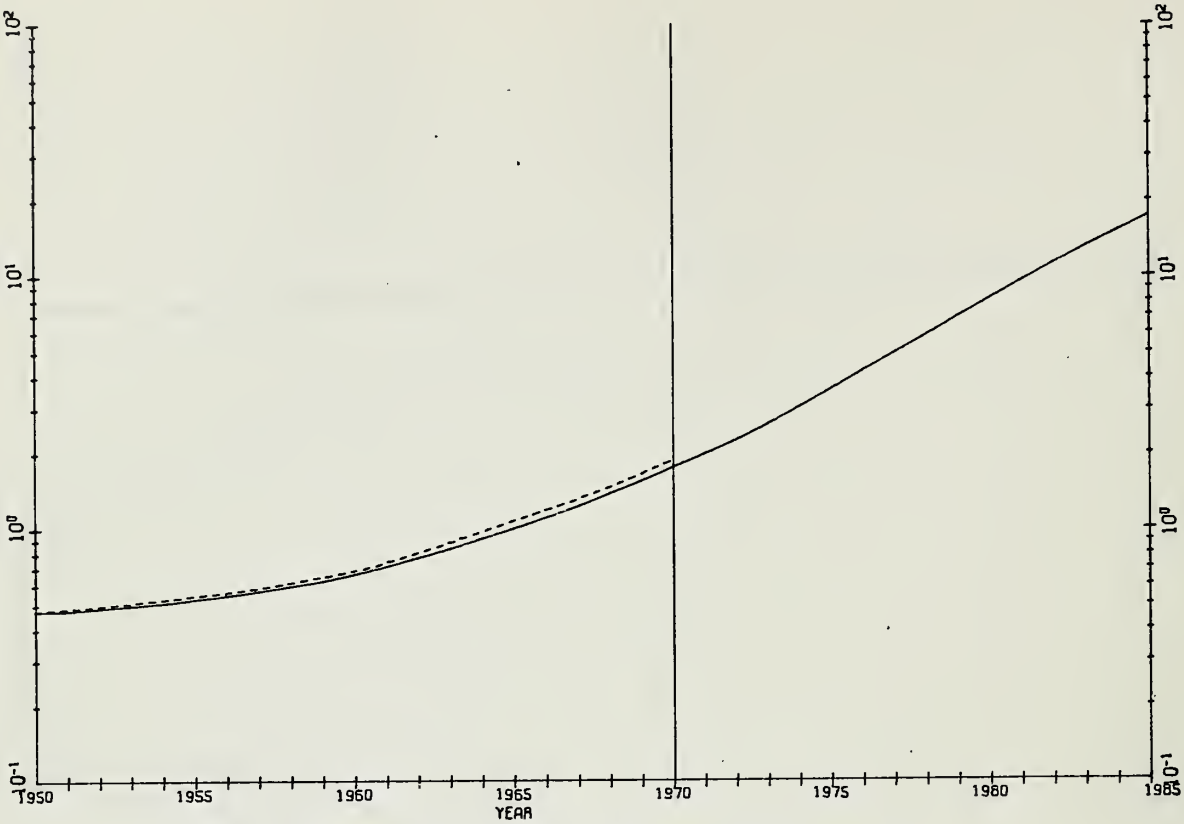

Figure 4-50. Capital Stock Density (Billion Yen/Square km)

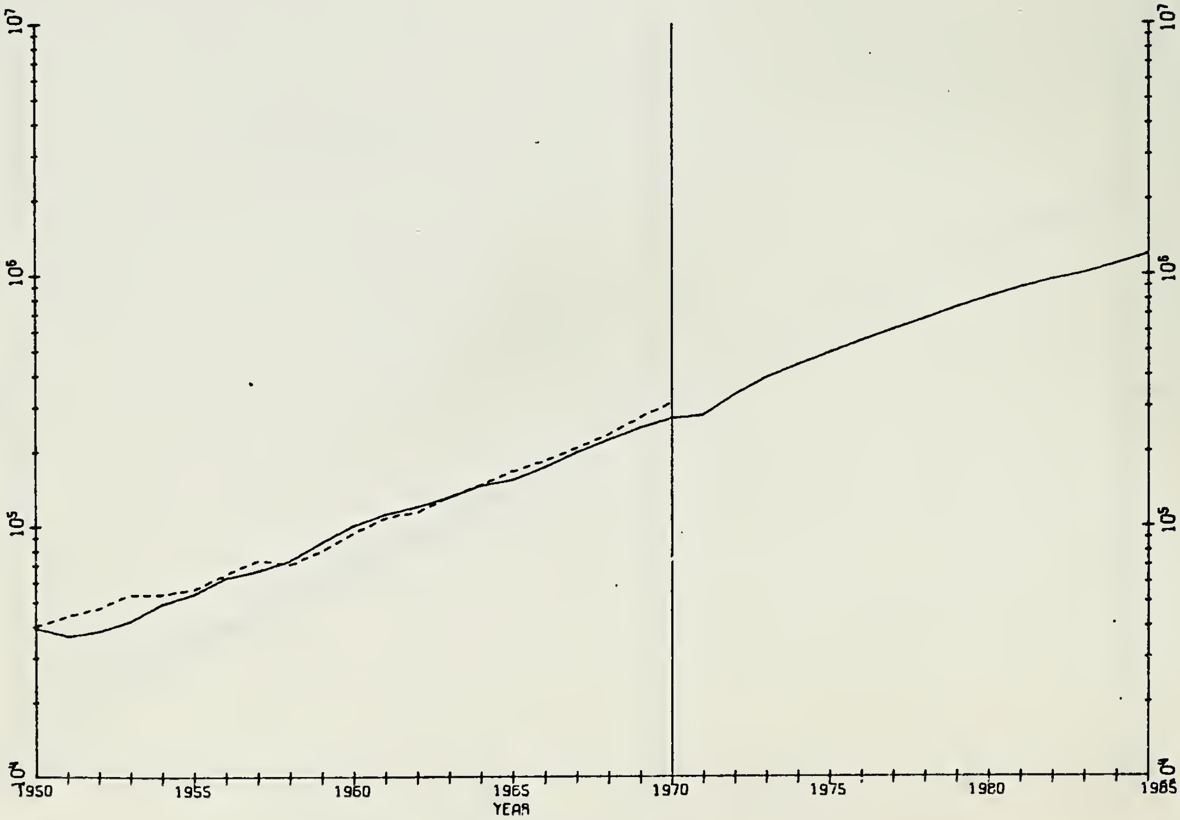

Figure 4-51. Energy Consumption (10**10 Kcal)

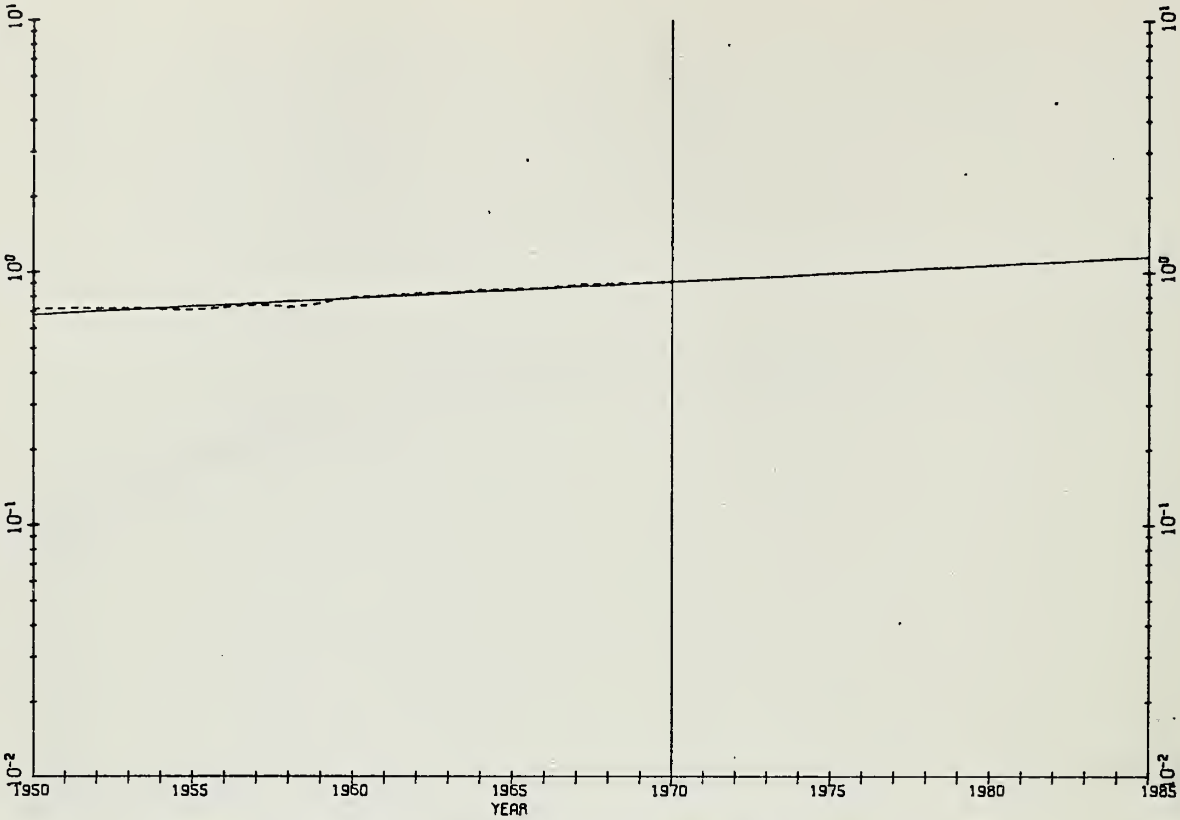

Figure 4-52. Share of Petroleum and Coal in Total Energy Consumption

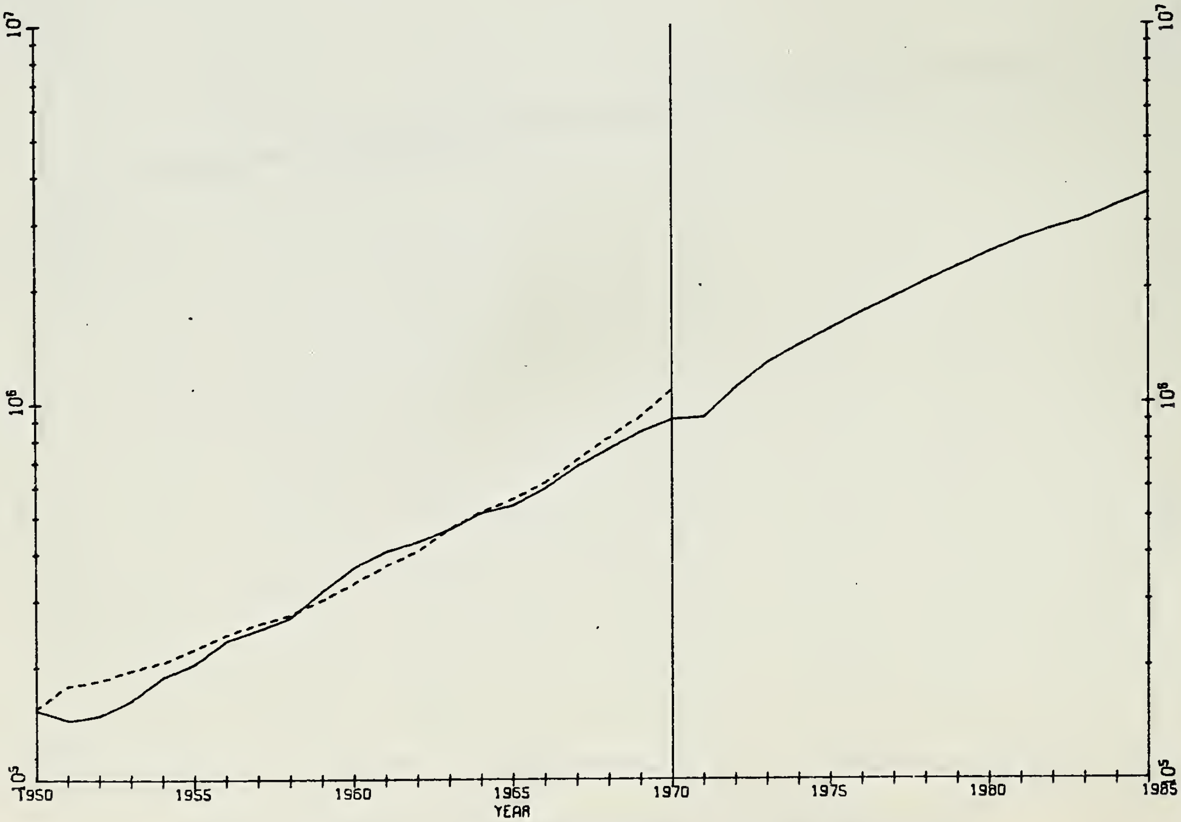

Figure 4-53. Transportation Activities (Millions of km)

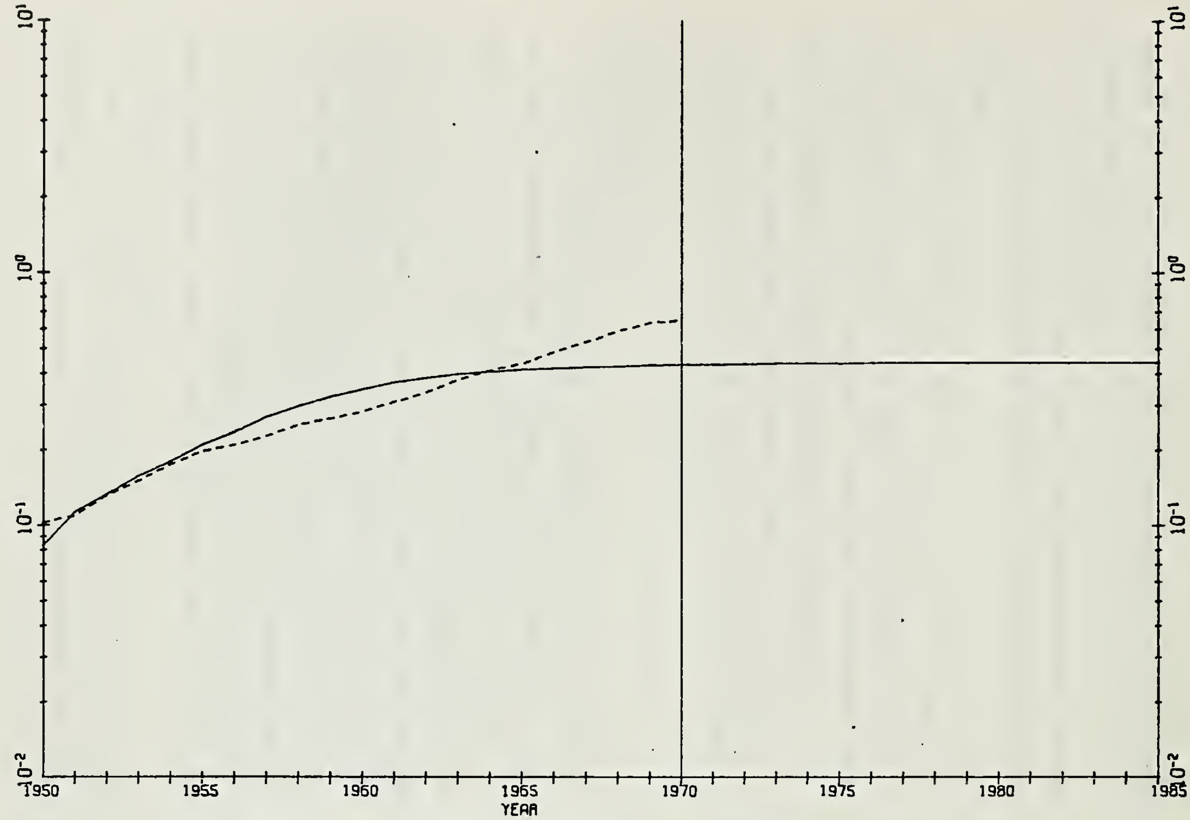

Figure 4-54. Share of Motor Vehicles in Transportation Activities

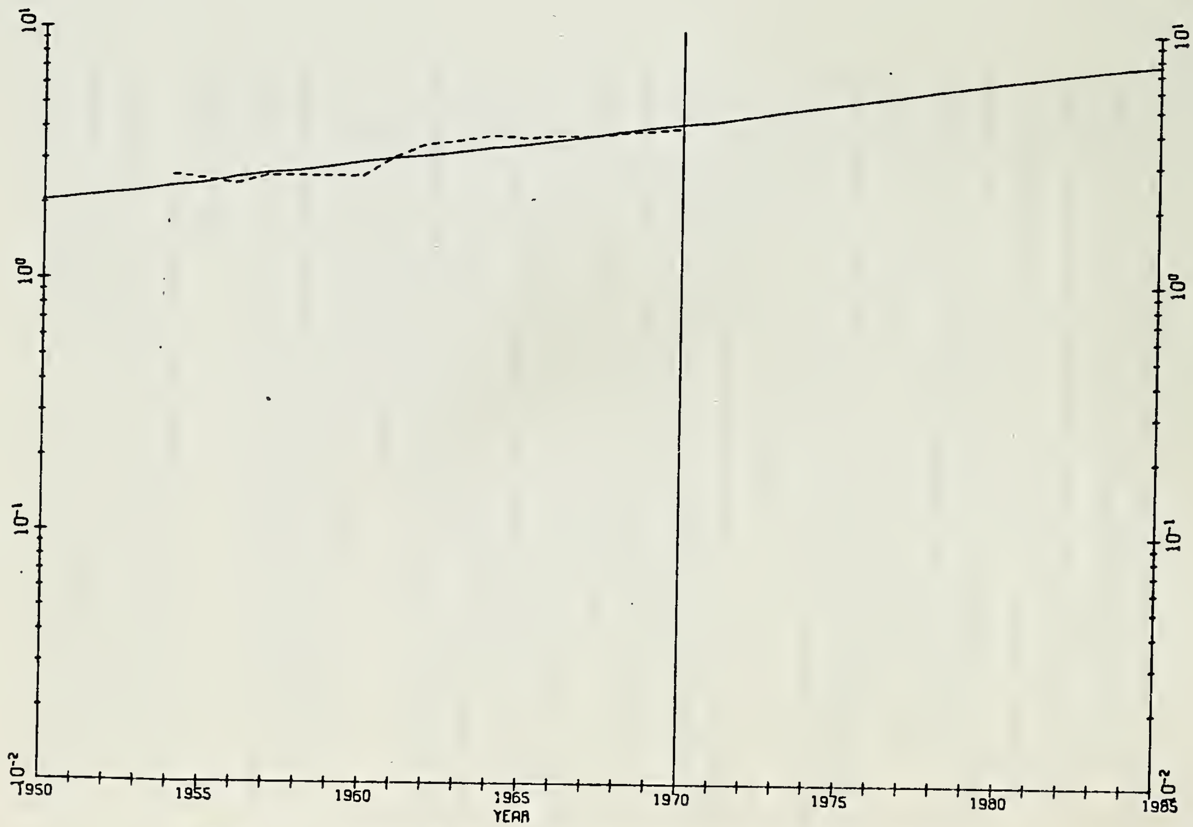

Figure 4-55. Regional Relocation of Population, Interprefectural (Percent)

values for 1970; the simulation for the first period is simply extended to the extrapolation period.

The result of simulation is shown in the preceeding charts. Judging from the plot of 1950-1970 period, the model is successful in repeating the past.

As for the projection for 1985, no claim is made of the accuracy of the estimates, since, after all, they are point predictions. This is especially true when the sample size is small, e.g., air pollution level, water pollution level, and the percentage of uncollected waste.

With the above reservations, and with other reservations inherent in the use of econometric methods, the model is sufficiently reliable to be a basis for further studies and experiments.

4.4 Concluding Remarks

Extreme caution is necessary in analyzing and deriving conclusions and policy implications from the findings reported in this study. A number of restrictive assumptions concerning the nature of economic phenomena have been employed. The high level of aggregation used in the model, which was dictated by need to keep the size of the model manageable and by data availability, might be inappropriate in some cases. Many of the time series data and parameters were estimated by the author due to limited availability of official data relating to the extended economic system; thus, the results obtained may be sensitive to the particular sample period chosen. Each of these qualifications have been discussed in various parts of the study.

The fit of individual equations are found to be very good. Judging from the result of the simulation test for the sample period, the model

is successful in repeating the past. But in a limited model of this sort which does not pretend to predict what additional policies will be adopted, simulation of future years can be taker as "predictions" only in a very limited sense. No doubt there will be changes as policy is enacted into law. The simulations of this are projections of what would happen if past trends continued unchanged. Two main purposes of simulation for future years is (1) to detect discrepancies in the specification of the model and thus provide basis for further improvement of the model, and (2) to provide basis for policy simulations by providing trend solutions for endogenous variables.

To the extent that the assumptions made are plausible approximations to reality, and that the economic relationships during the 1950-1970 period will not be altered drastically in the prediction period, the following "predictions" can be derived for the future:

(1) Until 1985 at least, there is no problem foreseen for continued economic growth in the working of the economic production mechanism itself, even after taking into account the factors which are expected to exert negative effects on the availability of factors of production for the continued expansion of the economy.

(2) The price rise will continue, especially in the case of consumer prices, reflecting high primary products and service prices. However, there is no danger that the rising price level will turn into runaway inflation.

(3) Future growth is characterized by the widening of success in conventional economic welfare variables and reductions of the non-economic variables on which people place heavier emphasis as income levels go up. By 1985 environmental input will reach the point that 32

percent of land available for economic use will be used up for industrial, social, and housing capital stocks and more than total precipitation of water is required. Density of economic activity will continue to increase, making Japan a less pleasant place to live. The relative shortage of social capital will persist if present resource allocation is to continue.

(4) Therefore, the real constraints to continued expansion of the economy emerge from people's attitudes. The projection for 1985 presented here will be untenable judging from the preference already being widely expressed by people for more noneconomic welfare, even at the cost of economic welfare.

To a large degree this study has accomplished the basis purposes which motivated it. A functioning general empirical model of an extended economic system explicitly recognizing the interrelationships among economic and non-economic variables has been developed.

Much remains to be done. Experiments using the model to simulate various policies should be carried out. It may become necessary to expand or disaggregate the model partly or as a whole depending on the purpose of the experiment. This can be done relatively easily because the variables which are not commonly found in conventional macro-economic models, but are required in analyzing the extended system, are already obtainable from this model, and because the model is designed to permit future expansions.

FOOTNOTES FOR CHAPTER 4

[1] Goldberger (1964), pp. 364-378.

[2] Goldberger (1964), p. 372.

[3] Goldberger, Impact Multipliers and Dynamic Properties of the Klein-Goldberger Model, Amsterdam, 1959.

[4] The period used for the calculation is as follows:
Al: 1961 to 1970. The trend is opposite in preceding years.
Pm, Pmr, and Pw: 1959 to 1970. Up to 1959, these variables are characterized by post-World War II dip and two peaks caused by the Koren War and the Suez Crisis. For each of them more secular trend is observed throughout the 1960's.
Yw: 1950-1970.
YM/Y and YRD/Y: 1960-1970.
(1-m): 1960-1970. The size of armed forces relative to labor force became stable in the late 1950's, following expansion initiated prior to the Korean War.

[5] Judging from a marked drop of foreign transactions after August, our method may be overstating the magnitude of the change of exchange rate in 1971.

[6] Data from Nihon Keizai Shinbun, July 23, 1971; August 9, 1971; and May 15, 1972.

APPENDIX A

A SUMMARY OF EXISTING AGGREGATE ECONOMETRIC MODELS ON THE JAPANESE ECONOMY

Presented below is a summary of the survey on the existing econometric models on the Japanese economy which I made prior to the formulation of the prototype model proposed above. A brief survey was also made for long-term models in other economies, the result of which is not reported here.

According to our purpose, emphasis is placed on long-term growth and development models; short-term forecasting models are also included. I have omitted, however, fiscal models, monetary sector models, industry models (e.g., iron, and steel, electric), sectoral models (e.g., plant and equipment investment, foreign trade), and micro models (e.g. firm behavior). Interindustry models and integrated models are also excluded.

Of the aggregate models, EPA Model I (27 equation Keynesian type model, Oct. 1960), Japan Development Bank Model (short-term forecasting model), and Economic and Social Development Plan Model (60 equation model) are omitted due to lack of detailed information. The last of these is basically the same as the Medium-Term Economic Plan Model except for the use of new national income statistics series, some improvement in individual equations, and addition of deflators and inventory equations.

Econometric Models on the Japanese Economy

Model Name	Number of equations (of which definitions	Sample Period Q: quarterly A: Annual BA: biennual	Remarks	Source
TCER Model II	7 (2)	1963-56 Q	Simple Keynesian type	Fukuchi (1961); Uchida & Watanabe (1959)
TCER Model III	21 (10)	1951-57 Q	Simple Keynesian type	Fukuchi (1961); Mori (1960)
MITI Model I	13 (5)	1951-57 Q	Simple Keynesian type	Fukuchi (1961)
TCER Model IV	50 (17)	1926-59 A	Disaggregated Keynesian type for structural analysis	Fukuchi (1961)
MITI Model II	16 (5)	1952-57 Q	Keynesian type production oriented	Fukuchi (1961)
Ueno Model I	10 (4)	1952-57 Q	Simple Keynesian type	Fukuchi (1961); Ueno (1961)
ICU Model I	40 (20)	1953-59 Q	Large-sized Keynesian type	Fukuchi (1961)
Klein Model	10 (2)	1878-1937 5 year	Labor-population oriented development model	Fukuchi (1961); Klein (1961)
Klein Shinkai Model	22 (7)	1930-58 A	Keynesian plus labor and population	Klein & Shinkai (1963), Blumenthal
Ueno Model II	38 (16)	1920-58 A	Production index model	Fukuchi (1961); Ueno (1963)
TCER Model V	30 (12)	1953-64 Q	Large-sized Keynesian type	Mori (1963-1) (1963-2)
Okazaki Models	19 (4)	1954-61 Q	Keynesian cycle model; separate for upswing and downswing	P. Okazaki (1963)
Osaka University Model	164 (59)	1952-59 Q	Large-sized production and economic structure oriented model	Fukuchi (1961); Ichimura, et al. (1964); Ichimura
ICU Model II	618	1953-60 Q	Disaggregated to commodity groups	Fukuchi (1964-1) (1964-2)
EPA Long-Term Model I	7 (2)	1906-60 A	Development model	Economic Planning Agency (1965-2)
EPA Long-Term Model II	21 (9)	1906-60 A	Two sector development model	Economic Planning Agency (1965-2)
EPA Medium-Term Model	43 (19)	1954-62 B.A.	Keynesian type with wage and price determination	Economic Planning Agency (1965-2)
Bronfenbrenner Model	11	---	Growth model; formalization of N. I. Doubling Plan	Bronfenbrenner (1965)
Shishido Model	21	---	Qualitatic development; formalization N. I. Doubling Plan	Shishido
Ueno Model III	39 (10)	1920-61 A	Production index model	Ueno & Kinoshita (1965)
KO 504 Model	21	hypothetical (A)	Development model	Tsujimura & Nishikawa (1967-68-1) (1967-68-2)
Tatemoto, Uchida & Watanabe Model	26 (17)	1953-62 B.A.	Keynesian type with wage and price determination	Tatemoto, et al. (1967)
Japanese Agriculture Model	37 (10)	1910-65 A	Sector model	Yuize (1967)
ICU Model V	46 (14)	1954-63 A	Regional model	Fukuchi & Nobukuni (1968)
ICU Model III	34 (6)	1955-63 Q	Keynesian model with large monetary sector	Fukuchi (1968)
EPA Short-term Pilot Model	53 (30)	1954-67 Q	Keynesian stabilization model	Economic Planning Agency (1967); Shishido et al. (
ICU Model IV	91 (45)	1955 65 Q	Production model to analyse dual structure by firm size	Fukuchi & Oguchi (1969)
JERC Short-Term Model	71 (39)	1955-65 Q	Keynesian stabilization model	JERC (1969)
EPA Short-Term Master Model	125 (65)	1954-67 Q	Keynesian stabilization model	Economic Planning Agency (1970)

APPENDIX B

SUMMARY OF SELECTED WORKS ON SOCIAL INDICATORS AND WELFARE INDICATORS

The following is a summary of recent work on social indicators and welfare indicators. The indicators included in each work are listed and the corresponding variables, if any, in this study are shown. The indicators marked by x have a corresponding variable or variables and those marked by (x) have a related variable or variables in this study. The correspondence is for simple comparisons only and in many cases is not exact, due to differences in coverages or definitions.

Included here are works by Adelman; Biderman; U.S. Department of Health, Education, and Welfare; Sheldon and Moore; Maruo; Noda; The Ministry of Labor (Japan); Office of the Prime Minister (Japan); and The Economic Planning Agency (Japan). This is not meant to be an exhaustive survey of works related to social or welfare indicators.

Adelman's Sociopolitical and Economic Indicators

Source: Adelman (1967), pp. 16-17.

Number of indicators: 41 Of which included in this study: 19

Indicators		Corresponding Variables
1. Size of the traditional agricultural sector	x	L1, Y1, Q1
2. Extent of dualism	(x)	Y1/L1 vs. Y2/L2 or W2/L2
3. Extent of urbanization	-	
4. Character of basic social organization	-	
5. Importance of the indigenous middle class	-	
6. Extent of social mobility	x	RR, $\frac{(L2/L)_t}{(L2/L)_{t-1}}$
7. Extent of literacy	(x)	E
8. Extent of mass communication	-	
9. Degree of cultural and ethnic homogeneity	-	
10. Degree of social tension	-	(dissonance may be measured; see text)
11. Crude fertility rate	x	b
12. Degree of modernization of outlook	-	
13. Degree of national integration and sense of national unity	-	
14. Extent of centralization of political power	-	
15. Strength of democratic institutions	-	
16. Degree of freedom of political opposition and press	-	
17. Degree of competitiveness of political parties	-	

Indicators		Corresponding Variables
18. Predominant basis of the political party system	-	
19. Strength of the labor movement	(x)	l
20. Political strength of the traditional elite	-	
21. Political strength of the military	(x)	m, $\dot{Y}M/Y$
22. Degree of administrative efficiency	-	
23. Extent of leadership commitment to economic development	-	
24. Extent of political stability	-	
25. Per capita GNP in 1961	x	Y/N
26. Rate of growth of real per capita GNP	x	$\frac{Y/(N \cdot P)_t}{Y/(N \cdot P)_{t-1}}$
27. Abundance of natural resources	(x)	Zair
28. Gross investment rate	x	S/Y
29. Level of modernization of industry	(x)	K2/L2
30. Change in degree of industrialization since 1950	x	$Q2_{1970}/Q2_{150}$, $L2_{1970}/L2_{1950}$, etc.
31. Character of agricultural organization	-	
32. Level of modernization of techniques in agriculture	(x)	K1/L1
33. Degree of improvement in agricultural productivity since 1950	x	T, Q1/L1, Q1/K1
34. Level of adequacy of physical overhead capital	x	Ks/K2, Ks/N
35. Degree of improvement in physical overhead capital since 1950	x	$(Ks/K2)_t$, $(Ks/N)_t$

Indicators		Corresponding Variables
36. Level of effectiveness of the tax system	-	
37. Degree of improvement in the tax system since 1950	-	
38. Level of effectiveness of financial institutions	-	
39. Degree of improvement in financial institutions since 1950	-	
40. Rate of improvement in human resources	x	E, ad, ai, at, v, da, db
41. Structure of foreign trade	(x)	X, M, B

Biderman's Summary List of Social Indicators in State of the Union Messages

Source: Bauer, ed., p. 93

Number of indicators: 17 Of which include in this study: 13

Indicators		Corresponding Variables
Economic Indicators		
1. Total activity and income statistics	x	Y
2. Markets and production	x	Q1, Q2
3. Income (distribution)	(x)	Y/N, Y1/L1, Y2/L2, W2/L2
4. Productive resources	(x)	Zair
5. "Sound" currency	(x)	P, Pc
6. Employment rates	x	u
7. Surpluses (Treasury)	-	
8. Debts	-	
9. Sales of public land	-	
Non-economic Indicators:		
10. Population	x	N
11. Technological advances	x	T, YRD
12. Education	x	E
13. Military appropriations	x	YM
14. Utilities and transportation	x	EC, TA
15. Government growth	-	
16. Natural resources	(x)	Zair
17. Welfare	x	da, db, ad, ai, at, 1, LE

HEW's Social Indicators

Source: U.S. Department of Health, Education, and Welfare, pp. ix-x.

Number of indicators: 25 Of which included in this study: 11

Indicators		Corresponding Variables
1. Infant mortality	x	db
2. Maternal mortality	-	
3. Family planning services	-	
4. Deaths from accidents	x	ai, at
5. Numbers of persons in state mental hospital	-	
6. Expectancy of healthy life	(x)	LE
7. Three- to five-years-old in school or preschool	-	
8. Persons 25 and older who graduate from high school)	(x)	E
9. Persons 25 and older who graduate from college)		
10. Persons in learning force	x	E
11. Percent of major cities with public community colleges	-	
12. Number of first-year students in medical schools	-	
13. Handicapped persons rehabilitated	-	
14. Average weekly hours of work	x	H
15. Labor force participation rate for women aged 35-64	(x)	L/L*
16. Average annual paid vacation	-	
17. Housing units with bathtub or shower	(x)	Kh/N
18. Percent of population illiterate	-	

Indicators		Corresponding Variables
19. Voters as a percentage of voting age population	-	
20. Public philanthropy as a percent of GNP	-	
21. Public and private expenditures for health, education and welfare as a percent of GNP	-	
22. Percent of population in poverty	(x)	Y1/L1, Y2/L2, W2/L2
23. Income of lowest fifth population	-	
24. Persons who work during the year	x	L
25. Life expectancy	x	LE

Sheldon and Moore's Social Indicators

Source: Sheldon and Moore (1966), pp. 189 ff.

Number of indicators: 16 Of which included in this study: 11

Indicators		Corresponding Variables
The Demographic Base:		
1. Total population	x	N
2. Age-sex composition	(x)	N*
3. Fertility	x	b
4. Mortality	x	da, db
5. Regional & residential redistribution of the population	x	RR
Major Structural Components:		
6. Production of goods and services	x	Q1, Q2, Y
7. Labor force and occupation	x	L1, L2e, L2u
8. Knowledge and technology	x	T, YRD
9. Family and kinship	-	
10. Religion	-	
Distributive features:		
11. Consumption	x	Cf, Cc, Cd
12. Recreational and expressive activities	-	
13. Health	x	ad
14. Education	x	E
Aggregative features:		
15. Social stratification and mobility	-	
16. Cultural homogeneity	-	

Maruo's National Welfare Indicators

Source: Maruo, 1971-1, p. 20

Number of indicators: 41 Of which included in this study: 18

Indicators		Corresponding Variables
Economic Welfare Indicators:		
(1) Level of Living:		
1. Per capita income	x	Y/N, Y*/N, W2/L2
2. Per capita assets	(x)	(K1+K2+Ks+Kh)/N
(2) Stability of Living:		
3. The rate of change of real personal income	x	$\frac{(Y/N)_t}{(Y/N)_{t-1}}$, $\frac{(W2/L2)_t}{(W2/L2)_{t-1}}$
4. Price index	x	P, P1, P2, Pc, Ps, Pa
5. Unemployment rate	x	u
6. Ratio of social security expenditure to GNP	-	
7. Per capita social security payment	-	
8. Deficit of the balance of payments	x	B
9. Price index of real assets	x	Pa
(3) Equality of Distribution:		
10. Percentage of income from assets	-	
11. Personal income distribution	-	
12. Wage differentials of various kinds	(x)	Y1/L1 vs. W2/L2
13. Regional income differentials	-	
14. The asset income distribution	-	

Indicators		Corresponding Variables
Non-economic Welfare Indicators:		
(1) Respect for Human Lives:		
15. Death rates from traffic accidents	x	at
16. Death rates of expectant and nursing mothers	-	
17. Infant death rates	x	db
18. Homicide death rates	-	
19. Life expectancy	x	LE
(2) Environmental Indicators:		
A. Health and sanitation indicators:		
20. TB patient rates)		
)	x	ad
21. Legal infectious diseases rates)		
22. Hospital beds per population	-	
23. Doctors and nurses per population	-	
B. Living environment indicators:		
24. Air and water pollution	x	ZBOD, ZSO2, ZCO
25. Number of houses and rooms per population	(x)	Kh/N
26. Diffusion rates of waterworks and sewerage	x	zwater
27. Acreage of urban parks per population	-	
C. Working conditions indicators:		
28. Work-days lost due to strikes	x	1
29. Commuting (congestion, time spent)	-	
30. Annual work days & daily work hours	x	H

Indicators		Corresponding Variables	
D.	Educational, cultural, and information indicators:		
31.	Illiteracy rate	-	
32.	Number of teachers per population	-	
33.	Rate of enrollment in higher education	x	E
34.	Diffusion of computers	-	
E.	Leisure indicators:		
35.	Leisure hours	(x)	H
36.	Diffusion rate of second house, the frequency of travel overseas for pleasure	-	
(3)	Alientation Indicators:		
37.	Suicide rate	-	
38.	Drug addicts	-	
39.	Mental disability rates	-	
40.	Participation to social system	-	
41.	Number of concert halls, art museums, and museums per population	-	

Noda's Non-monetary Levels of Living Indicators

Source: T. Noda, p. 20.

Number of indicators: 7 Of which included in this study: 7

Indicators		Corresponding Variables	
1.	Food	x	Cf
2.	Clothing	(x)	Cc
3.	Housing	x	Kh
4.	Heat and light	x	EC
5.	Health	x	db, ad, LE
6.	Education and culture	x	E
7.	Transportation and communication	x	TA

Ministry of Labor's Welfare Indicators of the Workers

Source: Labor White Paper, 1971, pp. 193-195.

Number of indicators: 13 Of which are included in this study: 11

Indicators		Corresponding Variables
Income and Assets:		
1. Income	x	W2/L2, Y2/L2, Y1/L1
2. Assets	(x)	Σ Cd, K2/N
Employment:		
3. Development of talent and skill	(x)	E
4. Employment opportunity	x	L2
5. Employment stability	x	u
Private life:		
6. Housing	x	Kh
7. Commuting	-	
8. Health and safety	x	ad, at
9. Leisure	(x)	H
Working conditions:		
10. Length of work	x	H
11. Stability of labor relations	x	1
12. Income and medical insurance	-	
13. Safety	x	ai

Office of the Prime Minister's Social Consciousness Indicators

Source: Economic Planning Agency, People's Living White Paper, 1971, pp. 344-345.

Number of indicators: 18 Of which included in this study: 14

Indicators		Corresponding Variables
Positive aspects of economic growth:		
1. Material abundance	x	Cf, Cc, Cd, Σ Cd
2. Increase in assets including savings and housing	x	Kh
3. Increase in employment opportunity	x	L2, u
4. Increase in leisure	(x)	H
5. Expansion of social facilities	x	Ks
6. Better international position	-	
7. Confidence and hope for the people	-	
8. Narrowing of economica differentials	(x)	Y1/L1, Y2/L2, W2/L2
9. Advance in science and technology	(x)	T, YRD
Negative aspects cf economic growth:		
10. Pollution	x	ZBOD, ZSO2, ZCO, Zwaste
11. Price increase	x	P1, P2, P, Pc, Ps, Pa
12. Traffic accidents and traffic congestion	x	at, TA, TD
13. Housing problem	x	Kh
14. Excessive density or sparsity	x	ND, YD, KD, TD
15. Widening of economic differentials	(x)	Y1/L1, Y2/L2, W2/L2
16. Labor shortage	(x)	L1/L, u
17. Loss of spiritual composure and emotion	-	
18. Dry human relations	-	

EPA's Indicators of People's Living

Source: Economic Planning Agency, People's Living White Paper, 1971, pp. 367-387.

Number of indicators: 56 Of which included in this study: 15

Indicators		Corresponding Variables
Consumption expenditure per household:		
1. Total	x	Cf, Cc, Cd
2. Foods	x	Cf
3. Main foods	-	
4. Foods outside household	-	
5. Furniture and equipment	x	Cd
6. Rent	-	
7. Fuel and light	-	
8. Clothing	(x)	Cc
9. Miscellaneous	-	
10. Medical expenses	-	
11. Transportation and communication	-	
12. Education	-	
Diffusion of durable consumer goods:	x	Σ Cd
13. Piano	-	
14. Vacuum cleaner	-	
15. Movie camera	-	
16. Drawing room sofa set	-	
17. Kerosene stove	-	
18. Stereo	-	
19. Men's suit	-	
20. Women's suit	-	
21. Dining table set	-	

Indicators		Corresponding Variables
Housing:	x	Kh
22. Number of house per person	-	
23. Floor space per person	-	
24. Units with flush toilet	-	
25. Owner rate	-	
26. Rent	-	
27. Residential land price	x	Pa
Transportation and Communication:	x	TA
28. Number of automobiles registered	-	
29. Total road length	-	
30. Percentage of road and highways improved	-	
31. Percentage of road and highways paved	-	
32. Telephones in use for household use	-	
Health:		
33. Death rate	x	da
34. Infant death rate	x	db
35. Number of physicians	-	
36. Number of hospital beds	-	
Education:		
37. Enrollment rate in colleges)	x	E
38. Enrollment rate in senior high schools)		
39. Number of students per instructor (senior high schools)	-	
40. Number of students per instructor (colleges)	-	

Indicators		Corresponding Variables
41. School building floor space per student (public primary schools)	-	
42. School building floor space per student (public junior high school)	-	
Public Service Facilities:	x	c·Ks
43. Urban parks	-	
44. Number of library books	-	
45. Nursery school capacity	-	
46. Gymnasium	-	
Public Safety:		
47. Crime rate	(x)	v
48. Fire	-	
49. Traffic accident injuries and deaths	x	at
50. Frequency rate of industrial accidents	x	ai
51. Number of firemen	-	
52. Number of fire engines	-	
53. Number of policemen	-	
Private Service Facilities:		
54. Number of coffee shops	-	
55. Bowling lanes	-	
56. Bars and cabarets	-	

APPENDIX C

LIST OF SAMPLE DATA

	Q1	Q2	P1	P2	Px	W2
	index 1965=100	index 1965=100	index 1965=100	index 1965=100	index 1965=100	billion ¥ current
1949	56.8	11.0	56.3	58.8	105.9	1133
50	61.2	13.3	57.3	72.7	92.6	1392
51	66.3	18.2	69.8	103.7	137.1	1920
52	71.8	19.5	72.2	104.8	121.5	2346
53	64.8	23.6	85.5	101.1	112.4	2890
54	69.7	25.5	82.8	101.2	107.8	3206
55	82.3	27.4	79.2	100.4	101.8	3480
56	79.3	33.8	77.4	105.2	106.1	3977
57	83.6	39.3	78.7	108.1	108.8	4509
58	84.7	38.8	76.1	100.2	105.6	4919
59	87.7	46.5	77.5	100.8	107.0	5520
60	90.8	58.0	81.8	100.9	109.4	6398
61	94.2	69.2	89.0	100.5	106.3	7625
62	97.3	74.7	89.4	98.5	103.7	9091
63	95.6	83.2	95.8	99.4	102.5	10682
64	98.5	96.3	96.0	99.6	101.3	12349
65	100.0	100.0	100.0	100.0	100.0	14303
66	103.0	113.1	107.4	101.8	101.1	16406
67	110.6	134.8	114.2	103.0	103.2	19023
68	112.6	158.3	121.2	103.3	103.3	22223
69	110.4	184.7	124.9	105.7	107.9	26017
70	108.0	214.3	125.4	110.1	113.9	31505

	Ps	Pa	P	Pc	Pm	Pmr
	index 1965=100	index 1965=100	index 1965=100	index 1965=100	index 1965=100	index 1965=100
1949	(34.5)	2.00	58.1	53.7	75.3	83.9
50	40.1	2.51	68.7	50.0	107.3	119.6
51	46.7	3.37	95.3	58.2	136.1	151.7
52	54.5	4.99	97.2	61.1	121.9	135.8
53	59.5	8.36	97.8	65.1	109.9	122.4
54	63.3	10.91	97.2	69.3	106.8	116.1
55	65.3	12.40	95.4	68.6	107.6	119.7
56	66.4	14.63	99.6	68.8	112.2	131.0
57	67.4	17.69	102.6	70.9	121.0	141.2
58	68.7	21.60	95.9	70.6	101.4	115.5
59	70.9	27.34	96.9	71.4	95.9	107.2
60	72.9	36.45	98.0	74.0	97.1	106.1
61	76.4	51.95	98.9	77.9	96.2	103.8
62	82.1	66.01	97.3	83.2	94.5	101.8
63	87.9	77.34	99.0	90.3	95.6	99.2
64	93.3	88.15	99.2	93.8	97.6	99.7
65	100.0	100.00	100.0	100.0	100.0	100.0
66	108.0	105.20	102.4	105.1	100.7	100.8
67	112.1	113.93	104.3	109.3	100.4	99.4
68	118.0	129.42	105.1	115.1	99.0	99.1
69	124.7	151.69	107.4	121.1	98.8	98.9
70	133.3	181.64	111.3	130.4	103.2	102.7

	Pw	Yw	Y1	Y2	Y	Y
	index 1965=100	index 1965=100	index 1965=1.00	index 1965=1.00	index 1965=1.00	billion ¥ current
1949	94.1		0.2607	0.0880	0.1076	3421
50	86.4	47.0	0.2902	0.1046	0.1256	3994
51	104.8	50.4	0.38-6	0.1468	0.1732	5508
52	101.9	52.5	0.3960	0.1666	0.1925	6122
53	100.0	55.9	0.4163	0.1968	0.2216	7047
54	96.1	57.3	0.4797	0.2184	0.2479	7883
55	96.1	62.9	0.5519	0.2354	0.2713	8624
56	98.0	64.9	0.5414	0.2759	0.3059	9726
57	100.0	67.7	0.5801	0.3190	0.3485	11080
58	97.0	69.1	0.5722	0.3357	0.3624	11522
59	95.1	73.9	0.6038	0.3814	0.4066	12926
60	97.0	78.1	0.6469	0.4672	0.4875	15499
61	96.1	81.5	0.7441	0.5835	0.6016	19126
62	96.1	85.7	0.7729	0.6533	0.6669	21199
63	97.0	89.1	0.8308	0.7618	0.7696	24464
64	99.0	94.6	0.8968	0.9085	0.9072	28838
65	100.0	100.0	1.0000	1.0000	1.0000	31787
66	101.9	106.1	1.1293	1.1522	0.1496	36545
67	101.9	110.6	1.3800	1.3530	1.3561	43107
68	100.9	117.6	1.4470	1.6297	1.6090	51148
69	104.8	126.5	1.4734	1.9299	1.8782	59705
70	(108.8)	(136.0)	1.5417	2.3070	2.2204	70580

	Cf	Cdindex	Ccindex	S	YM/Y	YRD/Y
	billion ¥ '65 prices	index 1965=100	index 1965=100	billion ¥ current	ratio	ratio
1949	597.1	3.4	14.8	632	0.0000	(0.0)
50	621.1	3.3	18.7	646	0.0033	(0.0)
51	683.1	4.4	24.4	1107	0.0038	(0.0)
52	749.9	5.5	27.0	1301	0.0170	(0.0)
53	687.1	7.1	35.1	1577	0.0223	(0.0)
54	741.5	8.1	38.5	1688	0.0196	(0.0)
55	861.6	10.1	42.7	1705	0.0157	0.0065
56	826.7	14.4	46.8	2290	0.0138	0.0074
57	869.8	20.6	51.4	2946	0.0138	0.0084
58	868.6	25.9	53.2	2941	0.0131	0.0093
59	902.0	40.1	56.9	3435	0.0121	0.0103
60	944.0	53.4	62.0	4682	0.0105	0.0112
61	993.2	67.2	67.6	6370	0.0095	0.0116
62	1034.3	76.9	74.9	7136	0.0102	0.0130
63	1044.3	90.3	87.6	7875	0.0100	0.0126
64	1102.1	104.2	94.7	9404	0.0097	0.0129
65	1148.3	100.0	100.0	9767	0.0095	0.0130
66	1203.5	120.7	110.0	11344	0.0094	0.0128
67	1287.0	157.8	117.7	13965	0.0089	0.0135
68	1321.2	206.6	126.3	17328	0.0084	0.0145
69	1331.6	253.9	136.8	21015	0.0083	0.0149
70	1344.0	274.9	148.4	25173	0.0083	0.0154

	I1	I2	Is	Ih	Rkh	Rkh'
	billion ¥ '65 prices	billion ¥ '65 prices	billion ¥ '65 prices	billion ¥ '65 prices	billion ¥ '65 prices	
1949	47.9	598.3	346.9	83.3		
50	45.9	573.0	177.4	94.9	6.6	38.6
51	52.6	657.0	270.0	86.7	6.1	29.9
52	104.7	695.7	265.2	174.6	11.3	14.5
53	143.6	837.5	342.2	235.4	15.7	98.4
54	110.0	894.9	388.3	273.7	21.4	67.5
55	151.6	921.0	340.6	283.8	21.5	31.8
56	206.2	1311.7	327.9	329.8	27.6	27.9
57	192.7	1784.1	371.8	376.5	34.6	14.5
58	151.9	1874.0	458.0	450.0	42.0	22.1
59	170.0	2192.0	539.6	505.9	48.9	323.6
60	201.7	3099.5	673.9	659.0	66.1	21.7
61	286.0	4396.4	813.9	841.7	86.7	97.0
62	311.3	4785.0	1114.7	1032.4	98.1	24.2
63	330.8	5083.6	1252.5	1256.5	108.0	24.4
64	389.9	5991.6	1430.7	1630.5	140.0	86.3
65	379.1	5825.8	1603.0	1957.0	184.2	40.9
66	429.2	6596.2	1905.6	2212.1	222.7	48.5
67	540.5	8306.0	1976.6	2733.0	299.4	53.5
68	780.9	10327.5	2290.4	3373.6	362.4	35.8
69	861.4	12494.2	2526.9	3998.1	442.0	36.2
70	957.6	14438.3	2781.1	4685.7	506.6	26.9

	Iz/I2	K1	K2	Ks	Kh	Kz
	ratio	billion ¥ '65 prices	billion ¥ '65 prices	billion ¥ '65 prices	billion ¥ '65 prices	billion ¥ '65 prices
1949		4005.9	19918.0	9865.2	10103.4	
50		4053.8	20516.3	10212.2	10186.7	
51		4099.7	21089.4	10389.6	10281.6	
52		4152.4	21746.4	10659.6	10368.4	
53		4257.2	22442.2	10924.9	10543.0	
54		4400.8	23279.8	11267.1	10778.4	
55		4510.8	24174.7	11655.4	11052.1	
56		4662.5	25095.7	11996.1	11336.0	
57		4868.8	26407.5	12324.0	11665.8	
58		5061.5	28191.6	12695.9	12042.3	
59		5213.4	30065.6	13153.9	12492.4	
60		5383.5	32257.6	13693.6	12998.4	
61		5585.2	35357.2	14367.6	13657.4	
62		5871.3	39753.7	15181.5	14499.2	
63		6182.7	44538.7	16296.2	15531.7	
64	(0.016)	6513.5	49622.4	17548.7	16788.2	(465.6)
65	0.0163	6903.4	55614.0	18979.4	18418.8	561.4
66	0.0148	7282.5	61439.5	20582.4	20375.8	657.0
67	0.0185	7711.8	68036.2	22488.1	22587.9	754.7
68	0.0190	8252.3	76342.2	24464.8	25320.9	908.5
69	0.0264	9033.2	86669.7	26755.2	28694.6	1105.1
70	0.0280	9894.6	99164.0	29282.2	32692.7	1435.6
71	0.0481					
72	0.0608					

	r	X	M	b	da	db
	ratio	billion ¥ current	billion ¥ current	ratio	ratio	ratio
1949		170	284	0.0329	0.0096	0.0624
50	(0.910)	298	348	0.0281	0.0091	0.0600
51	(0.950)	489	737	0.0252	0.0084	0.0574
52	(0.820)	458	730	0.0233	0.0077	0.0494
53	0.830	459	867	0.0214	0.0078	0.0489
54	0.825	587	864	0.0200	0.0072	0.0445
55	0.826	724	890	0.0193	0.0070	0.0397
56	0.916	900	1163	0.0184	0.0072	0.0406
57	0.952	1029	1542	0.0172	0.0075	0.0400
58	0.822	1036	1092	0.0180	0.0068	0.0345
59	0.865	1244	1296	0.0175	0.0068	0.0337
60	0.913	1460	1617	0.0171	0.0070	0.0306
61	0.915	1525	2092	0.0168	0.0068	0.0286
62	0.840	1770	2029	0.0170	0.0070	0.0264
63	0.807	1963	2425	0.0172	0.0065	0.0231
64	0.820	2402	2858	0.0176	0.0065	0.0203
65	0.754	3043	2941	0.0185	0.0067	0.0184
66	0.784	3520	3428	0.0137	0.0065	0.0192
67	0.851	3759	4199	0.0193	0.0064	0.0149
68	0.885	4670	4675	0.0184	0.0064	0.0158
69	0.907	5756	5408	0.0184	0.0065	0.0142
70	0.906	6954	6797	0.0186	0.0066	0.0131

	e	LE	N	N*	E	H
	ratio	years	thousand persons	thousand persons	thousand persons	hours per month
1949	-0.00138	58.0	81780	54850	2462	182.1
50	-0.00027	59.7	83200	55240	2824	187.6
51	-0.00021	62.8	84541	56260	3228	192.2
52	-0.00017	63.7	85808	57440	3572	192.1
53	-0.00012	63.8	86981	57010	3872	194.4
54	-0.00026	65.5	88239	58080	4042	193.7
55	-0.00117	66.1	89276	59250	4165	194.8
56	-0.00102	65.5	90172	60500	4359	199.3
57	-0.00107	65.4	90928	61750	4616	198.4
58	-0.00114	67.3	91767	69250	4850	198.0
59	-0.00144	67.5	92641	64240	5079	200.1
60	-0.00042	67.8	93419	65200	5199	202.7
61	-0.00016	68.4	94287	66030	5133	201.0
62	-0.00015	68.7	95181	67550	5425	197.8
63	-0.00009	69.7	96156	69380	6207	196.6
64	-0.00006	70.3	97182	71220	7027	195.7
65	-0.00029	70.7	98275	72870	7578	192.9
66	-0.00039	71.0	99031	74320	7720	193.2
67	-0.00034	71.5	100186	75570	7664	193.0
68	-0.00022	71.7	101316	76780	7566	192.7
69	-0.00025	71.9	102520	77820	7423	190.0
70	-0.00000	0	103720	78760	(7305)	187.7

	L	L1	L2	m	u	l
	thousand persons	thousand persons	thousand persons	ratio	ratio	ratio
1949	36440	19615	16821	0.00000	0.03027	0.00087
50	36160	19012	17144	0.00423	0.03424	0.00108
51	36600	17382	19215	0.00380	0.02728	0.00107
52	37750	17617	20129	0.00577	0.03125	0.00255
53	39890	17533	22353	0.00533	0.03171	0.00065
54	40550	16975	23571	0.00671	0.03778	0.00055
55	41940	15280	25620	0.00734	0.03937	0.00045
56	42680	14910	26800	0.00773	0.03527	0.00057
57	43630	14570	28240	0.00769	0.02821	0.00068
58	43870	13980	29000	0.00811	0.03010	0.00071
59	44330	13390	29970	0.00823	0.03166	0.00068
60	45110	13310	31060	0.00801	0.02357	0.00054
61	45620	12940	32040	0.00820	0.02018	0.00066
62	46140	12560	33000	0.00807	0.01756	0.00056
63	46520	11850	34090	0.00779	0.01701	0.00028
64	47100	11420	35120	0.00765	0.01514	0.00031
65	47870	11040	36260	0.00741	0.01547	0.00054
66	48910	10650	37610	0.00713	0.01698	0.00025
67	49830	10360	38850	0.00702	0.01595	0.00016
68	50610	9880	40140	0.00678	0.01448	0.00024
69	50980	9460	40940	0.00683	0.01373	0.00030
70	51530	8860	42070	0.00674	0.01383	0.00032

	ai	at	ad	v	A2hs	Zwater
	ratio	ratio	ratio	ratio	km^2	million m^3 per year
1949	0.01205	0.00005	0.00208	0.00176	9750	
50	0.01246	0.00005	0.00193	0.00171	9767	5990
51	(0.01070)	0.00006	0.00206	0.00165	9784	6542
52	0.01018	0.00006	0.00174	0.00132	9801	7147
53	0.00980	0.00007	0.00174	0.00133	9874	7806
54	0.00934	0.00008	0.00155	0.00134	9953	8488
55	0.00828	0.00008	0.00138	0.00140	10014	9314
56	0.00750	0.00010	0.00135	0.00133	10101	10112
57	0.00774	0.00011	0.00120	0.00126	10279	10995
58	0.00676	0.00012	0.00109	0.00125	10272	11961
59	0.00622	0.00014	0.00106	0.00119	10394	13129
60	0.00601	0.00016	0.00115	0.00110	10615	14423
61	0.00586	0.00017	0.00095	0.00104	10813	15858
62	0.00523	0.00016	0.00138	0.00097	11163	17449
63	0.00529	0.00018	0.00071	0.00092	11641	19531
64	0.00427	0.00019	0.00079	0.00088	12051	21594
65	0.00441	0.00019	0.00108	0.00086	12344	22287
66	0.00381	0.00022	0.00061	0.00084	12675	24251
67	0.00350	0.00025	0.00050	0.00076	12989	26500
68	(0.00331)	0.00030	0.00057	0.00070	13387	29552
69	0.00310	0.00034	0.00047	0.00064	13813	33422
70	(0.00310)	0.00034	(0.00047)	(0.00058)	(14256)	37822

	Zair	Zwaste	zwater	zwaste	ZBOD	ZSO2
	thousand tons per year	thousand tons per year	ratio	r..io	ppm	pphm
1949						
50	43283	13159	0.042			
51	51540	14892	0.069			
52	54133	15961	0.074			
53	62397	17580	0.079			
54	58485	19004	0.082			
55	59122	20502	0.083			
56	67324	22938	0.092			
57	80438	25258	0.100			
58	75986	26228	0.103			
59	79668	29654	0.104			
60	98057	34044	0.105		2.0	
61	115692	38467	0.123		2.8	
62	124025	40675	0.126		5.0	
63	135306	44402	0.141		4.3	
64	149960	50170	0.141		6.0	3.8
65	166289	52994	0.146	0.5431	4.8	4.9
66	183781	57467	0.153	0.5804	5.2	5.6
67	208913	66138	0.163	0.6277	7.7	5.6
68	233265	74268	0.180	0.6572	10.5	5.2
69	271468	84215	0.195	0.6987	5.4	5.2
70	312968	93581	0.210			4.5
71						3.3

	ZCO	Zs	EC	wpc	TA	wmv	RR
	ppm		10^{10}Kcal	ratio	million km	ratio	percent
1949							
50			39992	0.707	155200	0.1018	
51			43788	0.712	178415	0.1087	
52			47322	0.712	184021	0.1305	
53			53366	0.717	196078	0.1497	
54			53514	0.706	205886	0.1737	2.6
55			56016	0.704	223252	0.1965	2.5
56			64359	0.726	243653	0.2077	2.4
57			72952	0.742	259921	0.2262	2.6
58			70272	0.724	274313	0.2504	2.6
59			79501	0.754	[illegible]0382	0.2650	2.6
60			93749	0.798	332830	0.2823	2.6
61			108014	0.804	369463	0.3085	3.1
62			113895	0.825	403928	0.3360	3.5
63			130484	0.831	461839	0.3773	3.6
65	3.8	(0.025)	146117	0.851	513160	0.4119	3.8
65	4.1	(0.025)	165614	0.858	555005	0.4366	3.7
66	4.4	(0.025)	182552	0.867	612813	0.4865	3.8
67	4.9	0.025	205521	0.894	704731	0.5317	3.8
68	5.1	0.023	231778	0.902	807640	0.5868	3.9
69	6.4	0.021	270687	0.911	918122	0.6335	4.0
70	3.3	0.020	310468	0.915	1081894	0.6467	4.1
71	3.6						

APPENDIX D

SOURCES AND THE ESTIMATION PROCEDURE OF DATA

Note: In the following, Japan Statistical Yearbook (various issues) is abbreviated as SY.

Q1: Primary sector output is the combined production index of agriculture, forestry and fishery by Ministry of Agriculture and Forestry, Norinsho Tokeihyo (Statistical Tables of the Ministry of Agriculture and Forestry#) in SY. The items adopted are 102 for agriculture, 27 for forestry and 122 for fisheries.

Q2: Non-primary sector output is the production index for all industries including utilities, mining, and manufacturing. The items adopted are 404. The index is computed as a weighted arithmetic average, with value added as the weights. Original data from Ministry of International Trade and Industry, Tsusan Tokei (Statistices of International Trade and Industry#) in SY.

P1: Wholesale price index of agricultural, forestry, fishing, and hunting products from the Statistical Department, the Bank of Japan, Keizai Tokei Geppo (Economic Statistics Monthly*). See Hundred-Year Statistics of the Japanese Economy, and SY.

P2: Since there is no price index to cover all of the products, P2 is calculated from the general wholesale price index (P) and primary product price index (P1). The national income by industrial origin is used to obtain the weights for the two sectors. For source of the wholesale pri[illegible], see P below.

Px: Unit value index based on F.O.B. transaction value. Ministry of Finance, Gaikoku Boeki Gaikyo (Summary Statistics of Foreign Trade#).

W2: Compensation of employees in national income statistics is assumed to represent compensation of employees in the non-primary sector on the ground that the weight of employees in the primary sector is very small. Economic Planning Agency, Kokuminshotoku Tokei Nenpo (Annual Report on National Income Statistics*).

Ps: Index of miscellaneous prices from Office of the Prime Minister, Shohisha Bukka Shisu (Consumer Price Indexes) in SY is used as the service price index. Miscellaneous prices include items such as medical care, personal care, transport and communication, private transportation, education, reading and recreation, stationery, tobacco, and others. For recent years only, the above source also gives the service price index which includes private house and room rent, public services, personal services, and meals outside the home. In those years for which both "miscellaneous" and "service" prices are given, they move very close together.

Pa: Average of commercial, residential, and industrial land prices in 140 urban districts. The Japan Real Estate Institute, Zenkoku Shigaichi Kakaku Shisu (All Japan Urban Land Price Indexes#) in Hundred-Year Statistics of Japan and SY.

P: The Bank of Japan, Keizai Tokei Geppo in Hundred-Year Statistics of Japan and SY.

Pc: Office of the Prime Minister, Shohisha Bukka Shisu Nenpo (Annual Report on Consumer Price Index) in Keizai Hakusho 1971, p. 23.

Pm: Unit value index for imports based on C.I.F. transaction value. Ministry of Finance, Gaikoku Boeki Gaikyo in SY.

Pw: U.N. Yearbook of International Trade Statistics, various issues. Communist countries are excluded. The figure for 1970 is provisional estimated by the rate of increase in 1969.

Yw: U.N. Statistical Yearbook, various issues. Services of general government and private organizations are excluded. The 1970 figure is estimated based on the growth rate in 1969.

Y1index: Because there is no GNP data by industrial origin, the index of value added in the primary sector is estimated as $(Y \cdot wy1)/Y1_{1965}$, where

Y = GNP, current value,

$wy1$ = share of the primary sector in national income by industrial origin in each year, and

$Y1_{1965}$ = base year (1965) value of value added in the primary (3598.29 billion yen) calculated as $Y \cdot wy1$.

For data source, see Y below.

Y2index: Estimated as $(Y \cdot wym2)/Y2_{1965}$ where,

Y = GNP, current value,

$wy2$ = share of the non-primary sector in national income by industrial origin ($wy1 - wy2 = 1$), and

$Y2_{1965}$ = base year (1965) value of value added in non-primary sector (28188.71 billion yen) calculated

as Y·wy2.

For data source, see Y below.

Yindex: GNP converted to index, 1965 as the base year. For data source, see y.

Y: Economic Planning Agency, Kokuminshotoku Tokei Nenpo, various issues.

Cf: Food consumed is calculated as the total of domestic and imported primary products, adjusted for final demand as food. This is expressed as

Cf = (Q1 value + M1 value) x F.D. ratio

where Cf: food consumption,

Q1: domestic primary production index,

M1: primary product imports, and

F.D. ratio: final demand ratio, which is 0.6003.

Domestic primary production index series is Q1 explained earlier. To convert index number to value terms, base year (1965) value of 1382.7 billion yen is obtained from 1965 I-D table. See The Administrative Management Agency, et al., Showa 40-nen Sangyo Renkanhyono Kaisetsu Mikatato Riyono Shikata, 1969, p. 29. Q1 value series is then obtained by multiplying the index series and the base year value.

Primary product imports is obtained in current prices from Ministry of Finance, Gaikoku Boeki Gaikyo, various issues. This is deflated by the primary product import price index obtainable from the same source.

In order to obtain the share of final demand in total primary production, we first calculate the ratio of primary goods consumed as food to total supply from data prepared by F.A.O. See SY, 1968 edition, p. 255.

The data include annual figures for total production, changes in stock, imports, exports, and net food supply of 18 categories of food for 1963-1967 period. Second, we obtain the weight of each category in total primary goods production index from the Ministry of Agriculture and Forestry, Norinsho Tokeihyo as reported in Monthly Statistics of Japan, March 1971, p. 14. Third, we adjust the weights by the ratio consumed as food which we obtained in the first step. The sum of these adjusted weights, which is 0.6003, is used as the final demand ratio.

In the second step above, industrial crops, other crops, sericulture, and forestry products are all considered to be intermediate goods and are excluded.

As a check on the reliability of the estimation procedure, we found an alternative series by calculating the share of household and other than household consumption expenditure in the total of intermediate and final demand. This is found to be 0.2015 in 1965 I-O table. By multiplying this figure and total supply of primary goods we can obtain a series very closely corresponding to the one we have adopted here.

Cdindex: Index of durable consumer goods production from Ministry of International Trade and Industry, Tsusan Tokei (International Trade and Industry Statistics#). See SY.

Ccindex: Index of non-durable consumer goods production. For data source, see Cdindex.

S: Gross fixed capital formation. For data source, see Y.

YM/Y: Y is GNP figure; see Y for source. YM is defense expenditure in the national budget. Ministry of Finance, Zaisei Tokei (Public Finance Statistics#) reported in Hundred-Year Statistics of Japan, pp. 133-135, and SY, various issues.

YRD/Y: The ratio of research expenditure to gross national product is given in Science and Technology Agency, Kagaku Gijutsu Yoran (Science and Technology Handbook#). The ratio is assumed to be zero for 1950-1954 when data are unavailable. For 1956-1959 and 1961, figures are obtained from data for 1955 and 1960 given in Kanamori (1971), Tokyo, p. 131 by interpolation. The original source of this material is also Kagaku Gijutsu Yoran cited above.

I1: Estimated by the following procedure. First, the total of primary and non-primary sectors capital formation is obtained from national income statistics by adding (1) gross capital formation, private sector, machinery and equipment, and (2) government sector, machinery and equipment. Second, the share of primary sector capital formation in total machinery and equipment investment is obtained from capital stock series in Kazushi Ohkawa, Miyohei Shinohara, and Mataji Umemura, eds., Estimates of Long-Term Economic Statistics of Japan Since 1868, Vol. 3. Capital Stock, p. 262 (for 1950-1960) and in Keiryo Iinkai Daisanji Hokoku, p. 821, for the period thereafter. The share for the

interim years was assumed to be at the 1960 level. Third, I1 is obtained by (I1 + I2)·(share of I1). This estimation procedure is necessary because (1) two sectoral division is not made in national income statistics and (2) capital stock series in the two sources above, and capital formation series recalculated from them, are considered not consistent with national income statistics which have constantly been revised. Finally, the constant price series was calculated using the non-primary sector price index (P2) as deflator.

I2: See I1 for data source and the estimation procedure. I2 is obtained by (I1 + I2) times the share of I2.

Is: Social capital formation series is the item for General Government, Cross Fixed Capital Formation by Government Sector. The data are from Economic Planning Agency, Kokuminshotoku Tokei Nenpo (Annual Report on National Income Statistics*). Constant price figures are obtained by deflating the non-primary sector price index (P2). For 1949-51, the relative share of the item General Government in total fixed capital formation is assumed to be at the 1952 level.

Ih: Housing capital formation includes the items "Dwellings; Private Sector" and "Dwellings; Government Sector" in national income statistics. For data source, see Is. Constant price figures are obtained by deflating by the non-primary sector price index (P2).

Rkh: Housing capital removal statistics are available only in floor area. In order to make it comparable to housing capital formation statistics which are in value terms, the following estimation is made. First, the total floor area of residential buildings removed is taken from Ministry of Construction, Kenchiku Dotai Tokei Geppo (Monthly Report on Dynamic Building Statistics#) found in SY, various issues. Second, total floor area of dwelling construction started is taken from the same source, and the ratio of the removed floor space to the new floor space is calculated. This ratio is then multiplied by the housing capital formation in value terms (Ih) to obtain Rkh.

Rkh': Total floor area of residential buildings damaged is from Kenchiku Dotai Tokei Geppo as reported in SY. Following the same procedure as Rkh, Rkh' is obtained by multiplying (1) the ratio of the floor area damaged to the floor area of dwelling construction started and (2) housing capital formation in value terms. The main causes of damage include fire, storms and floods, and earthquakes.

Iz/I2: The Ministry of International Trade and Industry, Minkanni Okeru Sangyo Kogai Boshi Katsudono Genkyo (Current Situation of Industrial Pollution Prevention Measures in Private Sector#), 1972, as reported in Nihon Keizai Shinbun, January 25, 1972 and February 25, 1972.

Since the original data refer to those branches of industry which fall under MITI's jurisdiction (i.e., manufacturing, mining, and electricity and gas), we need to adjust it to our definition

of non-primary sector which includes all branches of the producing sector other than primary. According to the Economic Planning Agency, Keizai Hakusho (Economic White paper) 1971, p. 21, manufacturing, mining, and electricity and gas industries comprise 52.9% of the total investment in machinery and equipment. Although this ratio is changing over time, as can be seen in the Annual Report on National Income Statistics, we assume that the 1970 ratio has prevailed for the period 1965-1972 for which data on pollution prevention investment are available.

The ratio of Iz to I2 for the earlier period is assumed constant at 1.6%; the assumed level corresponds to the estimated 1965 level. The figures are on payment basis (as opposed to construction basis). The Survey covers only those firms with capital of more than 50 million yen. We assume that the ratio of pollution prevention investment in the total investment is the same for firms with a smaller amount of capital.

K1: We take the 1960 figure of primary capital stock in Ohkawa, Shinohara, and Umemura, eds., p. 262 as the base value, which is then converted from 1960 prices to 1965 prices. The annual series on primary sector capital formation is then successively added or subtracted from the base value to obtain K1 series. Depreciation is not considered.

K2: Same as K1, except that non-primary capital stock and non-primary capital formation figures are used.

Ks: We take the base figure from Research Bureau, Economic Planning Agency, Showa 30-nen Kokufu Chosa Sogo Hokoku (Comprehensive Report on the National Wealth Survey, 1955#). This survey was conducted as of December 31, 1955 on the assets of national, public, and private ownership existing in Japan (including those which exist abroad). The tangible fixed assets are estimated by the resupply value obtained by subtracting the decrement from the equivalent to reproduce or acquire the same objects toward the end of 1955. We assume that social capital is the total of buildings and structure which are under either national or public ownership. Dwelling houses are excluded. Also excluded are assets owned by operative government organizations (postal service, national forestry, printing, coinage, and alcohol monopoly), government corporations (Japan National Railways, Japan Telegraph & Telephone Corporation, Japan Monopoly Corporation, two banks, and four finance corporations), operative public corporations, and incorporated or unincorporated profit seeking private organizations.

Since our capital stock series are defined gross of depreciation, we have to adjust the figures in the National Wealth Survey to conform to our definition. The average age of the assets at the time of the Survey is unavailable to us, and it is assumed that the 1955 value represents 20 per cent of the value gross of depreciation. If we assume that the 1955 figure represents 30 per cent of the reacquisition value, the value of social capital in that year amounts to 7678 billion yen instead of 11,655 billion yen as adopted here (in 1965 prices). The 1955 value of social capital is converted to 1965 prices using the price index of

investment goods as the deflator. Finally the annual investment in social capital is added to or subtracted from the base year value.

Kh: Base year value for 1955 is determined from National Wealth Survey 1955, ibid. Housing capital in 1955 is the figure given for dwelling houses, including both public and private ownership. Since our capital stock series is defined gross of depreciation, the figure is adjusted, as in the case of Ks, by assuming that the 1955 figure is equivalent to 30 per cent of the renewal cost. The average age of housing capital stock is assumed to be younger than the social capital stock considering the fact that most of the Japanese dwelling buidlings were of wooden structure at the time of the Survey. The figure is then converted to 1965 prices using the building material price index as the deflator. The housing capital stock is obtained by adding or subtracting the annual housing capital formation.

Kz: First, the annual value of pollution prevention investment is calculated, using the share of pollution prevention investment in the total non-primary sector capital formation. Assuming that the initial value of pollution prevention capital in 1950 is zero, investment figures are accumulated to give stock value for each year. Since Iz/I2 ratio itself is assumed constant for 1950 to 1964 and the figures thereafter are subject to the assumptions described under Iz/I2, the reliability of Kz series is rather limited.

r: Economic Planning Agency, Keizai Hakusho (Economic White paper), 1971, p. 282 gives data on actual production, production capacity, and the ratio of gap between the two (1 - actual production. production capacity). Therefore the rate of capacity utilization can be obtained by resubtracting the gap ratio from unity. Since the original data is quarterly, annual figures are obtained as the average of quarterly figures. For the period 1950 to 1952 for which data is not available, we assume that the capacity utilization resembled the figures for 1956-1958. Judging from data on business cycles (e.g., the Bank of Japan, Wagakuni Keiki Hendo Shihyono Sokutei Bunseki (Estimation and Analysis of Business Cycle Indicators of Japan), 1958), these two periods constitute two cycles (May 1951 and February 1954 as the peak, respectively) of approximately the same magnitude.

X: Customs Bureau, Ministry of Finance, Gaikoku Boeki Gaikyo (Summary Statistics of Foreign Trade#).

M: Same as X.

b: Calculated as live births/population. Health and Welfare Statistics Division, Minister's Secretarist, Ministry of Health and Welfare, Jinko Dotai Tokei (Vital Statistics*) and Jinko Dotai Tokei Geppo (Gaisu) (Preliminary Monthly Reports on the Vital Statistics*) in SY.

da: Calculated as (total deaths - infant deaths)/population. For data source, see b.

db: Calculated as (infant deaths)/(live births). For data source, see b.

e: Calculated as (migration + adjustments between censuses)/population. Note that the net emigration rate defined here includes net social increase (immigrants - emigrants) and adjustments between population surveys which is proportionate of the difference between population estimates obtained by adding or subtracting the natural change and net migration and the figures obtained from the next base population enumerated in the census or survey.

LE: Average of male and female life expectancy; Economic Planning Agency, Kokumin Seikatsu Hakusho (White paper on People's Life#) 1971, p. 427.

N: (Health and Welfare Statistics Division, Minster's Secretariat), Ministry of Health and Welfare, Jinko Dotai Tokei (Vital Statistics*) in SY.

N*: Bureau of Statistics, Office of the Prime Minister, Rodoryoku Chosa Hokoku (Labor Force Survey) in SY.

E: Statistics Section, Minister's Secretariat, Ministry of Education, Gakko Kihon Chosa Hokokusho (School Basic Survey*) in SY. The survey is taken as of May 1 of the year stated. The total of students enrolled in senior high schools (including those for blind, deaf and handicapped), colleges and universities, and miscellaneous schools.

H: Labor Statistics and Research Division, Minister's Secretariat, Ministry of Labor, <u>Rodo Tokei Nenpo</u> (Annual Report on Labor Statistics#) in SY. Industries included are mining, construction, manufacturing, wholesale & retail trade, finance & insurance, real estate, transport & communication, and electricity, gas & water. Data refer to the stablishments with 30 or more regular workers. Figures represent the actual hours worked per worker, averaged for twelve months.

L: Bureau of Statistics, Office of the Prime Minister, <u>Rodoryoku Chosa Hokoku</u> (Labor Force Survey) in SY. This survey covers the population 15 years old and over usually residing in a sample of approximately 26,000 households. The survey method was partly revised in September, 1967. The series adopted here is from Japan Productivity Center, <u>Katsuyo Rodo Tokei</u> (Practical Labor Statistics) 1971, Tokyo, which gives adjusted figures for pre-revision years to be considered with figures under the revised method. For the period 1949-1954 for which adjusted figures are not available, the figures are adjusted by calculating annual percentage changes from the pre-revision series.

L1: Employed persons in agriculture, forestry, and fisheries. <u>Katsuyo Rodo Tokei</u> cited above classifies total labor force to agriculture & forestry, and non-agriculture; to make industrial classification conform to ours, employed persons in fisheries and aquiculture are reclassified using figures in the survey. No adjustment is made for the revision of the survey method for fisheries and aquiculture.

L2: Employed persons in mining; construction; manufacturing; wholesale and retail trade; finance; insurance and real estate; transport, communication, electricity, gas and water; and services and government plus wholly unemployed. Wholly unemployed are those not employed who are able to work, wish to work and are looking for work. It is assumed that the wholly unemployed are part of the non-agricultural labor force. For sources of data, see L and L1.

m: The number of personnel in Self-Defense Forces stipulated in the budget, including those both in uniform and not in uniform, as the ratio to the non-primary sector labor force (L2). Data on military personnel are from Boei Sangyo Kyokai (Defense Industries Association), <u>Jieitai Nenkan</u> (Self-Defense Forces Year Book#); Boei Nenkan Kankokai (Defense Year Book Publishing Co.#), <u>Boei Nenkan</u> (Defense Year Book#); and Defense Agency, <u>Kieitai Junenshi</u> (Ten Year History of the Self Defense Forces#), 1961, Tokyo.

u: Calculated as unemployed/L2. Note that the unemployment rate is defined as the ratio with the non-primary labor force alone, not including the primary sector labor force. Naturally, the rate is higher than when calculated in relation with the total labor force, including the primary labor force. The primary labor force in Japan largely consists of self-employed farmers, with considerable size of disguised unemployment. This kind of "unemployment" is not considered in the Labor Force Survey. Denoting employed by e and unemployed by u, we consider that the total labor force consists of L1e + L1u + L2e + L2u. Of these categories,

Lle and Llu are considered inseparable in this study. The category "wholly unemployed" in the Labor Force Survey is considered unemployed in L2 category. This is not to say that "wholly unemployed" figures reflect the true state of the non-primary labor market. Rather, they should be considered merely an indicator of employment status because, besides the fact that the definition of unemployment precludes underemployment caused by lack of employment opportunity, under Japanese employment practice, the unemployment rate reacts sluggishly to business cycles and probably understates the true state of unemployment in recession years. These points are not considered in this paper. For source of data, see L.

l: Data on days lost due to labor disputes, including both strikes and lockouts, are obtained from the Ministry of Labor, Rodo Sogi Tokei (Labor Disputes Statistics#) and Rodo Tokei Chosa Geppo (Monthly Report on Labor Statistics Research#) in SY. These figures are then converted to man years lost using 284.4 days as one man year. This conversion rate is obtained by multiplying the average monthly work days in 1964 by twelve. See the Bank of Japan, Hundred Year Statistics of Japan, p. 62. Finally the ratio to the total non-primary labor force is calculated.

ai: Labor Statistics and Research Division, Minister's Secretariat, Ministry of Labor, Rodo Saigai Doko Chosa Hokoku (Survey Report on the Trend of Industrial Accidents#) in SY. Data are based on the Workmen's Accident Trend Survey which covers the accidents occurring to the wage earners employed in all the public and

private establishments with 100 workers or more. Establishments with only managerial, clerical, and technical workers are excluded. Also excluded are the sailors covered by Article 1 of the Seamen's Law, who are engaged in traffic enterprises using ships. Since the original data is given in severity rate which is defined as the ratio of the number of days lost (multiplied by one thousand) to the total man-hours worked, it is multiplied by work hours per day (assumed to be eight) and divided by 1000 to obtain the man year lost as the ratio to total man years. In order to adjust for the coverage, the share of workers in mining, construction, and manufacturing industries is obtained from the Labor Force Survey for each year and multiplied with the ratio calculated as above. Electricity and gas industries are covered by the original statistics, but their share is not taken into consideration in calculating the share of workers covered by the Survey because they are grouped with other categories. It is assumed that the occurrence of industrial accidents for firms employing less than 100 workers is the same as those employing 100 or more. This might result in understating the occurrence of accidents (for example, establishments with 30 employees and more report severity rate of 1.01 while those with 100 employees or more report 0.90).

at: Total of man years lost due to railway and road accidents is first estimated and the ratio to the total population is calculated as (at). A simplifying assumption here is that traffic accident victims are evenly distributed among age groups, sexes, and occupations. Data are from the Computer Department, Japan National Railways, Tetsudo Yoran (Railway Handbook#), Private

Railways Division, Railway Supervision Bureau, Ministry of Transportation, Shitetsu Tokei Nenpo (Annual Report on Private Railways#), and Patrol Traffic Bureau, Policy Agency, Kotsujiko Tokei (Traffic Accident Statistics#) reported in SY. In order to correct figures on persons killed or injured from these sources into man years lost figures, we assume ten days lost for each person injured (fourteen days for 1949-1959 when slight damage)--injury of less than eight days and property damage or less than 20,000 yen--were not required to be reported in the case of road accidents and one-half of a man year for each person killed. The use of hypothetical figures for days lost is necessitated due to unavailability of empirical data. Finally, the man-day figure is converted to the man-year figure and the ratio to the total population is calculated.

ad: Cases of infectious diseases are from the Health and Welfare Statistics Division, Minister's Secretariat, Ministry of Health and Welfare, Densenbyo oyobi Shokuchudoku Tokei (Statistics on Infectious Diseases and Food Poisoning#) in SY. Cases of various diseases are simply added. Included diseases are dysentery, typhoid fever, paratyphoid fever, scarlet fever, diphtheria, meningococcal infections, Japanese "B" encephalitic (above are legal infectious diseases), acute poliomyelitis, malaria, measles, whooping cough, influenza, tetanus, anthrax, infectious diarrhoea, Japanese river fever, filariasis, schistosomiasis, trachoma (above are designated and reportable infectious diseases), venereal diseases, tuberculosis and leprosy. In order to obtain man-years lost, we use patient days per case reported in the National Health Survey which was taken for a sample of household

during seven days of October 12-18, 1966. Patient days per case of 45.5 days is reported for infectious and parasitic diseases. Minister's Secretariat, Ministry of Health and Welfare, Showa 41-nen Koseisho Seikatsu Sogo Chosa (Ministry of Health and Welfare Comprehensive Survey of Life, 1966#). Finally, the man year lost is expressed as a ratio of the total population. It is assumed that there is no difference in the illness rate between people in the non-primary labor force and those in the general population.

v: Judicial System and Research Division, Minister's Secretariat, Ministry of Justice, Kyosei Tokei Nenpo (Correction Statistics Annual Report#). The above source gives the number of inmates as of end of year, which we regard to represent the number of inmates throughout the year. The ratio of inmates to population of 15 years old and over is calculated to give inmates rates.

A2hs: Land used for non-primary industry, housing capital, and social capital is the total of residential, railway, road, and industrial land. The estimation method is as follows.

Residential land is from the Taxation Bureau, Ministry of Home Affairs, Kotei Shisanno Kakakutono Gaiyo Chosho (Summary Report on Prices, etc. of Fixed Assets#) in SY. Data refer to the lands registered as of January of each year in the land ledgers. Excluded from the Report are non-taxable lands such as lands owned by government or local public bodies; lands for official or public use; graveyards; public roads; sewers; reservoirs; reserved forests; private school sites; temple, shrine and church compounds; and others. Residential land figures are those under the heading,

"Residential land" in the Report. 1969 and 1970 figures are provisional ones estimated by the rate of increase in 1968.

Railway land is the total of land used for stations and railroads by Japan National Railways and private railways and tramways as reported in the Computer Department, Japan National Railways, Tetsudo Yoran (Railway Handbook#) and Tetsudo Tokei Nenpo (Railway Annual Statistics#) in SY. Figures for Japan National Railways for 1951-1954 and 1956-1959 are estimated by calculating the annual average increase from data for 1950, 1955 and 1960. For private railways figures are available for 1950, 1955, 1960, 1965 and annually thereafter. Estimation is made by calculating the annual average increase. The 1970 figure is provisional.

Road land is estimated by first estimating the length of road by condition (improved or unimproved, and classified by width) from the Road Bureau, Ministry of Construction, Doro Tokei Nenpo (Annual Report on Road Statistics#) in SY. Data refer to the national highways, prefectural roads, and city, town and village roads under the Road Law. "Improved" are those improved in width, gradient, curve, etc. in conformity with the Road Structure Rules enforced in 1963. "Improved" are assumed to be at the 1955 level for the 1950-54 period and "unimproved" at the 1960 level for the 1950-1959 period. Next, the average width for each class has to be estimated because the actual average is unavailable. Figures used here are as follows.

	Width class	Assumed average width
Improved:	less than 4.5 m	4.5 m
	4.5 - 7.49 m	6.0 m
	7.5 - 12.9 m	10.0 m
	13 m and over	20.0 m
Unimproved:	less than 4.5 m	3.0 m
	4.5 m and over	6.0 m

Industrial land is from Minister's Secretariat, Ministry of International Trade and Industry, Kogyo Tokeihyo Yochi·Yosuihen (Census of Manufacturers, Report on Industrial Land and Water*). The 1970 figure is estimated by the increased rate in 1969.

Zwater: Total of industrial water and water supplied by water works, with duplication adjusted. Industrial water data are from Kogyo Tokeihyo Yochi·Yosuihen, ibid. A survey on industrial water was taken in 1958 and has been conducted annually from 1961. Figures for 1950-1957 are estimates obtained by assuming that the same increase rate since 1958 had prevailed for that period. Although data on the use of sea water is given, figures adopted here include fresh water only. These statistics cover approximately 55,000 private manufacturing establishments with 30 or more persons engaged. Daily figures are converted to annual figures.

Data on water supplied by water works are from the Environment Sanitation Division, Ministry of Health and Welfare, Suido Tokei (Water Works Statistics#) in SY. The figures adopted here are the total of waterworks and simplified waterworks; exclusive waterworks

are omitted because of possible double counting with industrial water. Water supplies for industrial use is also excluded although some portion of it goes to manufacturing establishments with less than 30 persons engaged which are not covered by the survey on industrial water. An estimation is made for the years for which data are not obtainable (i.e., 1950, 1951, 1956-64, 1969 and 1970) based on the growth rate calculated from available data.

Zair: Total consumption of sulphur-containing resources is the total of imported and domestically produced coal, crude petroleum, heavy oil, and lignite. Although the sulphur content and heat value of these resources are different, they are simply added to obtain the total figure; one metric ton is considered equal to 1000 kiloleters in the calculation. Customs Bureau, Ministry of France, Gaikoku Boeki Gaikyo (Summary Statistics of Foreign Trade#); Research and Statistics Division, Minister's Secretariat, Ministry of International Trade and Industry, Kogyo Tokei Geppo (Monthly Report on Mining Statistics#); Sekiyu Tokei Geppo (Monthly Report on Petroleum Statistics#) in SY.

Zwaste: Total of household waste and industrial waste. Industrial waste is calculated by multiplying the industrial waste matrix and the industrial production index. The industrial waste matrix is from the Office of the Prime Minister, Economic Planning Agency, Ministry of Health and Welfare, Ministry of International Trade and Industry, etc., eds., Kogai Hakusho 1971 (Pollution White Paper), p. 146, which gives the output of industrial waste by physical nature and by industry. The data are based on a 1970 survey and cover 67 per cent of the value of the shipment of manufacturing and utility. The industrial production index is from the Minister's Secretariat, Ministry of International Trade and Industry, Tsusan Tokei (International Trade and Industry Statistics). Classification of industry of these two materials are identical with some minor differences due to the unification of industrial branches. No attempt is made here to calculate waste by physical nature or by industry, and only the total is obtained by adding output of waste by industrial branches to give total industrial waste output. Since this covers 67 per cent of the value of shipment in 1970, adjustment is made by dividing by 0.67. This estimation method, therefore, takes into account the changes in the composition of industrial branches over a period of time, but does not consider the changes in the waste output rate over a period of time which might have accompanied technological change.

Kogai Hakusho also gives the output of household waste per person per day for the five year period 1965-1969. For earlier years and for 1970, an estimation is made by using the average rate of increase during the five year period. The figures are then transformed to the annual aggregate figure, multiplied by 365 and by population.

zwater: Japan Sewerage Association-Ministry of Construction, Kokyo Gesuido Tokei (Public Sewerage Statistics#) in SY. The sewerage diffusion rate is defined as population under sewerage system divided by total population. One drawback of this definition is

that it does not convey the idea of necessity since the rural population may not require a sewerage system as does the urban population. A high diffusion rate coupled with an even higher rate of urbanization actually implies that the situation will become progressively worse, although this definition gives the impression that the situation is improving.

Some sources (for example, Economic Planning Agency, Kokumin Sei KatsuMakusho 1971 (White Paper on People's Life), p. 440) define the sewerage diffusion rate as the ratio of the area under sewerage systems to the area of urban districts. This definition gives a considerably higher rate than the one used here.

1961	19.3%
1962	19.6
1963	20.8
1964	23.6
1965	23.8
1966	24.7
1967	27.0
1968	28.6
1969	28.7

Urbanization is a difficult concept to define; if we use an administrative concept we should expect some discrepancy between an administrative urban area and the actual urban area due to administrative lag, for example. Our model does not explain urbanization, and this definition is not used to avoid introducing an additional variable.

zwaste: Kogai Hakusho 1971, p. 136 defines collection rate as the ratio of the quantity of waste actually collected and the total output

of waste under the collection plan district. Output of waste outside the designated district is, therefore, excluded. As a result, the collection rate is higher than the one used here, which is redefined as the ratio of actual collected waste to total output of waste including the area outside the collection plan. The total output figure is from output of waste, household. Data on the processing of industrial waste before disposal is available only for 1970 and is not considered here.

ZBOD: Kogai Hakusho 1971, ibid., p. 103. Data refer to Tama River, Tokyo.

ZSO2: Economic Planning Agency, Kokumin Seikatsu Hakusho, 1971 (White Paper on People's Life), p. 389. Data are based on research done by the Ministry of Health and Welfare and the City of Tokyo. Figures are the average of values recorded at observation posts in Tokyo.

ZCO: For source etc., see ZSO2.

Zs: Kogai Hakusho 1971, ibid., p. 226 gives the actual figure for 1967 and the target figures for 1973 and 1978. The fuels included are heavy oil, crude petroleum for direct burning, and liquid natural gas. The sulphur content before 1967 is assumed to be constant at the 1967 level; this assumption is plausible because there had been practically no effort to reduce the sulphur content prior to that year. Figures from 1968 to the present have been obtained by interpolating the 1967 and 1973 figures.

EC: Comprehensive Energy Policy Section, Minister's Secretariat, Ministry of International Trade and Industry, Sogo Enerugi Tokei (Comprehensive Energy Statistics#), 1971, pp. 152-163. Prime sources of energy in the above statistics are hydraulic, coal, coke, lignite, petroleum, natural gas, charcoal, and firewood. The 1950-1952 figures are estimates by growth of electricity supply. Public Utilities Bureau, Ministry of International Trade and Industry, Denki Jigyo Yoran (Handbook of Electric Industry#) in SY.

wpc: Total of weights of coal, coke, lignite and petroleum. The 1950-1952 values are estimated first by extrapolating the trend value for each item, and adding them. For source of data, see EC.

TA: Passenger-km and freight ton-km are simply added. Department of Research and Data Processing, Minister's Secretariat, Ministry of Transportation, Rikuun Tokei Yoran (Handbook of Land Transportation Statistics#) and Rikuun Tokei Geppo (Monthly Statistical Report on Land Transportation#) in SY. Freight ton-km includes national and private railways and trucks. Passenger-km includes national and private railways, buses, passenger cars for business use, reserved buses for business use, buses for private use, and private cars.

wmv: Ratio of motor vehicle transportation to total of railways and motor vehicle transportation. For source, etc., see TA.

RR: Prime Minister's Office, Jumin Toroku Jinko Ido Hokoku Nenpo (Annual Report on the Movement of Resident Registration Population#) in Economic Planning Agency, People's Living White Paper, 1971, p. 437.

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VITA

Kimio Uno was born in Tokyo, Japan, on January 19, 1941. He attended Keio Senior High School in Yokohama, Japan, graduating in 1959. He entered Keio University where he majored in economics, receiving a Bachelor of Arts degree in March 1963. He attended the Afro-Asian Institute in Tel Aviv, Israel, in the spring of 1962, and was an exchange student at Stanford University, California, during the summer of the same year. From 1963 to 1966, he was employed as an economic researcher by Hitachi, Ltd. of Tokyo, Japan. In April, 1967, he was admitted to the graduate program in economics at Keio University and obtained a Master of Arts degree in economics in 1969. In September 1969, he entered the University of Illinois as a graduate student in economics. For the academic years 1969 and 1972, he was a research and teaching assistant in the Department of Economics and at the Center for Advanced Computation.

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Center for Advanced Computation University of Illinois at Urbana-Champaign Urbana, Illinois 61801	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP
3. REPORT TITLE The Limits of Japanese Growth: An Econometric Study	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Research report	
5. AUTHOR(S) (First name, middle initial, last name) Kimio Uno	
6. REPORT DATE July 19, 1973	7a. TOTAL NO. OF PAGES 332 7b. NO. OF REFS 385
8a. CONTRACT OR GRANT NO. DAHC04-72-C-0001 b. PROJECT NO. ARPA Order No. 1899 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) CAC Document No. 80 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
10. DISTRIBUTION STATEMENT Copies may be requested from the address given in (1) above.	
11. SUPPLEMENTARY NOTES None	12. SPONSORING MILITARY ACTIVITY U. S. Army Research Office - Durham Duke Station Durham, North Carolina
13. ABSTRACT See front matter	

DD FORM 1 NOV 65 1473

UNCLASSIFIED
Security Classification