PNAAS-486

39428

# INTERSECTORAL FACTOR MOBILITY AND AGRICULTURAL GROWTH

Yair Mundlak

Research Report 6
International Food Policy Research Institute
February 1979

Copyright 1979 International Food Policy Research Institute

All rights reserved. Sections of this report may be reproduced with acknowledgement to the International Food Policy Research Institute.

Library of Congress Cataloging in Publication Data
Mundlak, Yair, 1927-
Intersectoral factor mobility and agricultural growth.

(Research report—International Food Policy Research Institute ; 6)
Includes bibliographical references.
1. Agriculture—Economic aspects—Japan—Mathematical models. 2. Rural development—Japan—Mathematical models. 3. Rural-urban migration—Japan—Mathematical models. I. Title. II. Series: International Food Policy Research Institute. Research report—International Food Policy Research Institute ; 6.
HD2092.M8 338.1'0952 79-4588

ISBN 0-89629-007-7

# CONTENTS

Foreword

1. A Framework for Analysis and Some Consequences — 11
   Yair Mundlak

2. Migration Out of Agriculture: Empirical Analysis — 19
   Yair Mundlak

3. Occupational Migration Out of Agriculture in Japan — 33
   Yair Mundlak and John Strauss

4. The Flow of Savings Out of Agriculture—The Case of Japan — 43
   Yair Mundlak and John Strauss

5. Agricultural Growth in the Context of Economic Growth — 56
   Yair Mundlak

6. A Quantitative Interpretation of Some Aspects of the Japanese Experience — 75
   Yair Mundlak and John Strauss

Appendix A The Data for Chapter 2 and Their Sources — 103

Appendix B Background of Chapter 3 Analysis — 106

Appendix C Estimating Saving Rates — 115

Appendix D A Description of the Simulator — 120

Appendix E Initial Values of Parameters and Variables Used in Chapter 5 — 125

Appendix F Data Sources for Chapter 6 — 127

Bibliography — 133

3

# TABLES


1. Estimates of migration equation ($M_1$), 70 countries, 1960-70 27
2. Estimates of migration equation ($M_1$), OECD countries, 1950-70 29
3. Estimates of migration equation ($M_2$) 30
4. Values of $\hat{\delta}(m = 0)$ for the OECD countries 31
5. Results of applying the CCS equation to postwar Japanese data 34
6. Estimates of the migration equation, postwar Japan 37
7. Alternative forms for the migration equation 39
8. Estimates of the flow equation for the prewar period, 1909-38 48
9. Postwar estimates of the savings flow equations, 1955-64 and 1954-70 49
10. Estimates of the savings flow equation, data pooled 50
11. The response of savings flow to differential returns on capital 53
12. Numerical solutions—selected results for $t = 21$ 68
13. Directional effects of parametric changes along growth path 72
14. Actual and simulated levels of some economic variables for prewar Japan 80
15. Actual and simulated levels of some economic variables for postwar Japan 89
16. Restrictions on resource flow, 1937 96
17. Restrictions of resource flow, 1968 97
18. Prewar economy with postwar technical change and saving rates, simulation results, 1937 99


4

19. Postwar economy with prewar technical change and saving rates, simulation results, 1968 100

20. Summary measures of the data 105

21. Migration and related variables, five-year averages, 1906-70 107

22. Means, coefficients of variation, and correlation coefficients for various variables, prewar and postwar periods 108

23. Estimating sectoral saving rates for the prewar period 117

24. Summary statistics, savings flow variables 119

25. Initial values of variables and parameters for basic runs 129

26. Restrictions imposed for completion of Tables 16 and 17 131

27. Restrictions imposed for completion of Tables 18 and 19 131

# ILLUSTRATIONS


1. Actual and Predicted Migration, Post World War II Japan 35

2. Migration Elasticities with Respect to Farm—Nonfarm Income Differences and to the Labor Force Ratio, Postwar Period Elasticity 40

3. Flow of Funds and Related Variables 1909-1938, 1955-1970 47

4. Momentary Equilibrium Determination 62

5. Actual and Simulated Per Capita Outputs, Prewar Period 83

6. Actual and Simulated Labor Force Levels, Prewar Period 84

7. Actual and Simulated Capital, Prewar Period 85

8. Actual and Simulated Terms of Trade Between Agricultural and Nonagricultural Sectors, Prewar Period 86

9. Simulated Wages and Capital Returns, Prewar Period 87

10. Actual and Simulated Per Capita Outputs, Postwar Period 90

11. Actual and Simulated Labor Force Levels, Postwar Period 91

12. Actual and Simulated Capital, Postwar Period 92

13. Actual and Simulated Terms of Trade Between Agricultural and Nonagricultural Sectors, Postwar Period 93

14. Simulated Wages and Capital Returns, Postwar Period 94

15. Annual Migration and Related Variables, 1905-1972 111

# FOREWORD

The appropriateness of an agricultural development strategy, the intensity with which that strategy is pursued, and the effect it has upon agricultural growth and fulfillment of nutritional and income needs all depend upon the nature of the interdependency and linkages between agricultural and other sectors of an economy. The importance of these links is emphasized by the frequent failure of effective demand for food to accompany increased agricultural production and by the too frequently encountered reticence of official growth-oriented planning agencies and finance ministries to accord high priority to the types of rural expenditures requiring massive resource allocation.

The research program of the International Food Policy Research Institute includes work on several aspects of this linkage problem, among which are analysis of the influences on effective demand for food, the sources of agricultural growth, and descriptions of production and consumption linkages of agriculture to the other sectors of the economy.

Research conducted by Yair Mundlak at IFPRI has led to the development of a model for analyzing the relation between particular aspects of agricultural growth and other sectors of the economy. The model is elegant and illuminating. Applied to Japan in this Research Report, it gives particular emphasis to the role of capital and labor flows among sectors and the effect of these flows upon growth. Yair Mundlak is currently applying the model to Argentine data, and exploratory discussion on using it with Mexican data is under way. As IFPRI's research on growth linkages increases, this model, and modified versions of it, will be useful in quantifying relationships and in diagnosing the potentials for faster, more efficient growth.

John W. Mellor

Washington, D.C.
February 1, 1979

# ACKNOWLEDGEMENTS

Much of the discussion on economic growth is inspired by stylized facts. The casual observer can easily discover that while the style has remained fairly constant over a long period of time, the facts vary a great deal over time and space. Thus, it is suggested that more insight can be gained by concentrating on the facts. I was fortunate and grateful to learn that IFPRI shared a similar view and was willing to sponsor its implementation in the study of agricultural growth. This research report brings together the first set of results of this study, some of which have been previously circulated as individual papers.

This study is largely empirical in nature and could not have been accomplished without the assistance of various individuals to whom I am greatly indebted. The burden of the empirical work was very skillfully carried out by John Strauss. The computer program for the numerical solution of the growth path was written by Selig Starr. The final stages of the computations were carried out by Diane Skellie.

Earlier drafts of some chapters were discussed at IFPRI seminars and were also read by Tuvia Blumenthal, James Gavan, Constantino Lluch, and Virabongsa Ramangkura. Their valuable comments affected the preparation of the final draft. This final draft was edited by Charlene Semer. Kate Hathaway and Barbara Barbiero were responsible for bringing the manuscript through the press.

# 1

## A FRAMEWORK FOR ANALYSIS AND SOME CONSEQUENCES

Most of the world's population still lives in countries that are largely rural, and the development of such countries is of general interest. The development of a rural economy is largely related to the development of its agricultural sector.[1] The agricultural sector is not isolated; however, it is interdependent with the rest of the economy through the factor and product markets, and changes in such markets affect all major sectors. This interdependence must be taken into account when important policy questions and measures are considered and evaluated. Specifically, the effects of changes in resource endowment and in supply of final or intermediate products (for instance, due to foreign aid) cannot be limited to one sector, and the feedback cannot be ignored. That, of course, also holds true with respect to price policies, changes in technologies, and any other important measures.

### The Framework of the Present Analysis

In dealing with the role of agriculture in the process of economic growth, it is important to have a conceptual as well as an operational framework which takes into account the relationships between agriculture and the rest of the economy. Such a formulation can be constructed at various levels of aggregation. The decision on the level of aggregation should largely depend on the questions asked: the more specific the question, the less aggregated the models. When disaggregation is carried far enough, however, the problem may well be studied within a partial rather than a general framework.

The present framework is general, and the analysis is carried out at the highest level of aggregation, which facilitates concentration on the process of agricultural growth. It should be noted that aggregation is not the invention of the analyst but is rather a result of the need to simplify. We talk about agriculture and agricultural policy or food and food policy under the assumption that they convey unambiguous meanings. When we need to deal with a specific product, we refer to that product. Similarly, the present framework could be disaggregated to any desirable, and yet meaningful, degree.

In order to be able to assess the consequences of development policies, it is necessary to understand the process of growth. The distinction between the two concepts is made here in order to emphasize that the concept of development implies some intervention in the process of economic growth. Intervention is generally motivated by the desire to achieve targets, such as higher rates of growth or im-

[1]This is also well recognized by policy makers. Cf. Chapter 2, "Policy and Strategy," National Commission on Agriculture, Government of India, Abridged Report (1976).

provement in the distribution of income or consumption, and it will result in altering the process of growth. A full understanding of these results requires evaluating them within a dynamic framework which allows comparing the growth paths that will occur under different intervention measures in any given economy.

There are various models that deal with sectoral growth in the context of general equilibrium.[2] However, the empirical relevance of such models has not been established. The main difficulty emerges from a rather fundamental methodological flaw: the process of resource allocation is detached from real time. To explain this point, reference is first made to neoclassical general equilibrium models, which assume that at any point in time factor prices are equal among the various sectors.[3] Geometrically, such equality is achieved by finding a point on the transformation frontier of the economy which also satisfies the demand conditions. Being on the efficiency frontier implies equal factor prices across sectors. Once this point is achieved, time is brought in by assuming a given rate of growth for the primary resources, and the growth path is evaluated.

There is nothing wrong with the logic of such a model, only with its relevance. This is particularly so with respect to labor surplus economies, in which reaching the point of factor-price equality may require several decades. To make the model more realistic, it is important to take explicit account of the fact that it takes time for resources to be allocated and that the rate of such allocation is an economically determined quantity. This is the approach of this work.

Chapter 5 presents the model and illustrates some empirical results. Basically, the model starts with the assumption that at any given point in time resource allocation is predetermined and, given the technology, the total product supply is also predetermined. Product prices are determined by the demand for final consumption and for investment. Given the technology and the resource allocation, factor shadow prices are determined, and they in turn determine the flow of resources from a sector of low to a sector of high returns. This resource flow, together with population growth and capital accumulation, determines the availability of resources to the two sectors in the next period. Adding the effects of changes in technology, product supply in that period is determined, and the process repeats itself.

This system can be described by difference equations which are solved numerically. The solutions are data specific; unlike analytic results, they are not data robust. But perhaps this is the strength, rather than the weakness, of the model. Growth scenarios are generated for given initial conditions, and it is quite likely that given exogenous changes will produce different effects on the growth paths in different countries. Some empirical applications are demonstrated.

The key relationships in this model are the intersectoral resource flows. Chapters 2 and 3 deal with labor migration, and Chapter 4 deals with the flow of savings out of (or

[2]Some of the models evolved from the work of W. A. Lewis on labor surplus economies: "Economic Development with Unlimited Supplies of Labor," *The Manchester School of Economics and Social Studies*, 22 (1954): 139-191, and "Unlimited Labor: Further Notes," *The Manchester School of Economics and Social Studies*, 26 (1958): 1-32. This model emphasizes some important aspects of the early stages of development but overlooks other aspects.

[3]Cf. Y. Mundlak and R. Mosenson, "Two-Sector Model with Generalized Demand," *Metroeconomica*, 22 (1970): 227-58.

into, as the case may be) agriculture. The basic premise in dealing with these flow equations is that the flow of resources is motivated by differential returns. This is hardly a new notion. Yet, as elementary as it is, it has not been documented sufficiently in the empirical literature. This fact may reflect misspecification of the basic equation. Chapter 2 discusses the specification of labor migration out of agriculture and applies it to country cross-section data. The advantage of such data is that they have a wide spread in the explanatory variables. The outcome is an empirical migration equation that relates the rate (per unit of time) of labor migration out of agriculture to economic variables.

The empirical migration equation is integrated into the model to produce numerical solutions. In this case, it is desirable to use an equation derived for the country under investigation. The difficulty with country data is that the spread in the explanatory variables is by far narrower than with the cross-section data. This problem is discussed in Chapter 3, which deals with the estimation of the migration equation for Japan.

Applying a similar approach to the flow of savings out of agriculture requires data which are not readily available. Chapter 4 deals with this problem, again using the data for Japan. There are no data based on direct observation of the rate of flow of savings out of agriculture, but estimates were constructed under alternative assumptions with respect to sectoral savings behavior. The resulting time series of the rate of flow is used to estimate the savings flow equation. This equation, like the labor migration equation, explains the rate of savings flow in terms of differential returns and other economic variables. Chapter 6 integrates these results and applies the model to the analysis of some of the issues related to the contribution of agriculture to economic growth in Japan.[4]

## Summary of Selected Results

An important feature of this analysis is that, in evaluating numerically growth paths of the economy, it is data specific. However, the way the model postulates the work of the system depends to a large extent on the process of intersectoral resource allocation. For this reason, the study of the intersectoral factor flow is of as much interest as the evaluation of the consequences of these flows. Together, these empirical analyses have general implications, both in terms of formulating the problem and in terms of the actual results. We therefore start our summary with the flow equations.

### Labor Migration

It has been postulated that the rate of migration out of agriculture is determined by the income differential between the two sectors, the composition of the labor force,

[4] Japan was selected for the empirical analysis in this volume for a combination of reasons: it has recently undergone the transformation from a largely rural to an industrial economy; it has good data which are readily accessible, and its experience has been analyzed by many writers, making it possible to draw on such analyses and to compare results.

the natural growth rate of the labor force, and some other related variables. A migration function was formulated that takes the role of each of these variables into account. The function was first fitted to data for 70 countries for the decade 1960 to 1970 (or thereabout) as well as for 17 Organization for Economic Cooperation and Development (OECD) countries for two decades, 1950 to 1960 and 1960 to 1970. For the 70-country sample, the average annual migration rate was 2.1 percent (of the agricultural labor force) and the range was from 0.2 to 6.7 percent. The variables used explain the intercountry differences in the rate of migration very well. Furthermore, for the subsample of the OECD countries, the results did not reveal a "decade effect," nor were there any important differences between the results obtained for the OECD countries and for the whole sample, which includes less developed countries. It appears, therefore, that the economic variables capture a good part of the systematic variations in the rate of migration.

There has been a great deal of discussion, which usually lacks any empirical content, as to how the income differential should be measured. In the present formulation, there is a built-in mechanism to find whether the particular variable used to represent income maintains the property that migration stops when the income differential disappears.

A similar analysis was conducted for Japan, which realized a rapid migration in the postwar years—the average migration rates were 1.1 percent for 1910-40 and 4.7 percent for 1951-72. The same formulation that was used for the country cross-section explained Japan's postwar migration well. In order to explain the prewar migration, the level of activity of the economy was also introduced into the analysis and new variables were created in order to reduce the number of parameters. By doing this, it was possible to pull the two periods together and develop a single equation that summarizes the Japanese experience.

### Flow of Savings

The development of the Japanese economy was accompanied by a flow of savings from agriculture to the rest of the economy. Measurement of this outflow was obtained by indirect calculations that depend on the saving rates in the two sectors. Although these saving rates are not known, they were estimated for the prewar data. The estimates indicate that saving rates in agriculture remained constant and relatively high and that saving rates in the rest of the economy were lower, but increased with per capita production in that sector. The savings flow series was obtained under various assumptions with respect to the ratio of saving rates in the two sectors.

The basic premise that was tested and empirically supported by this study is that the flow of savings can be attributed to differential returns to capital in the two sectors. The magnitude of the response of the savings flow to changes in differential returns depends on the data series used to measure the flow and to measure differential returns. The response of the flow, measured as a percentage of agricultural savings, to a change in differential returns on capital, measured in terms of average productivities, was .566 when saving rates were assumed to be equal in the two sectors; it was .214 when the agricultural saving rate was assumed to be twice that of the nonagricultural sector.

## Complementarity of Factor Flows

Savings flow plays an important role in the process of development. The flow is initiated by higher capital returns in the nonagricultural sector; that is, when there are better opportunities out of agriculture. In a static situation, the flow of savings tends to equalize returns in the two sectors, and eventually the flow will diminish. The process cannot be isolated from other processes, however. There is a flow of labor along with the flow of capital, and the two flows affect each other. The migration of labor out of agriculture increases the capital-labor ratio in agriculture, which reduces the rate of return on agricultural capital and increases it in the other sector. Thus, labor migration increases the differential in returns and augments the flow of savings. By a similar argument, the flow of savings augments the migration of labor. These complementary relationships between labor and savings flows imply that the low-income sector contributes to increases in both capital and labor in the high-income sector.

## Consequences of Factor Flows

The nature of the Japanese experience and the lessons to be drawn from it have been discussed by various authors. There is a general agreement among most writers that savings flows out of agriculture provided an important source of funds for the growth of the nonagricultural sector. The present framework was used to examine this issue as well as other related issues. Basically, the method of evaluating the importance of a particular variable is to compare the growth paths of the economy under various assumptions with respect to the value of that variable. For instance, in order to assess the importance of savings flow, a growth path is obtained under the assumption of no flow, and this path is compared with that obtained under the actual situation as reflected by the flow equation. This is simply an exercise in comparative dynamics in which the effect of a particular change is evaluated, not only in the present, but also in the periods that follow. In order to carry out this comparison, it was first necessary to fit the model to the Japanese data; that is, the empirical values that were selected for the parameters in question were those which generated growth paths reasonably close to the actual data.

This evaluation indicated that the contribution of the outflow of agricultural savings did not contribute much to the growth of the nonagricultural sector in Japan—at least not since 1907, the beginning year for the analysis. The quantitative effect of savings outflow has been by far less important than that of labor migration. Labor seems to be the dominant contribution that Japanese agriculture made to the growth of the nonagricultural sector.

Regardless of the verdict on the role of intersectoral savings flow, one can still conclude that social organizations that are conducive to the reallocation of resources in line with their relative returns contribute to economic growth. Other things being equal, the larger the intersectoral difference in returns, the larger the potential for growth from resource reallocation.

### Savings, Capital Accumulation and Technical Change

High saving rates in Japan, particularly in the postwar period, resulted in rapid capital accumulation. Thus, high saving rates are usually considered to be a major factor contributing to Japanese growth. It turns out, howeve., that the direct quantitative effect of this accumulation on growth is not conspicuously large. Those who believe that the effect of capital accumulation is pronounced may find it difficult to demonstrate this belief convincingly to a nonbeliever. Such an endeavor would probably require attributing to capital accumulation an important effect on technical change, along the lines of the embodiment hypothesis. If this approach proves to be successful, then it may also lead to modifying the view suggested here with respect to the quantitative effect of the savings outflow.

In considering such an approach, however, it might be noted that although the flow of agricultural savings financed only a relatively small fraction of nonagricultural investment, throughout most of the period the outflow represented a relatively large proportion of agricultural savings. Consequently, if technical change depends significantly on the rate of investment, then the savings flow should have created a wide gap between the rates of technical change in the two sectors. On the surface, this is not clearly supported by evidence, but it is a point that requires more attention.

Whatever the causes of technical change, it is clear that it played an important role in Japanese development. It basically freed agricultural resources to move into the nonagricultural sector.

## Some Reflections

Some of the reasons the present framework was chosen may not be readily apparent, and some aspects of the framework may raise questions or suggest directions for future analysis. These considerations call for some comments.

### Scope

Growth is generated by having more resources and by using them more efficiently. This is well known and for that reason, there is no need for frameworks of the kind discussed here. Furthermore, some important issues related to agricultural growth can be discussed without explicit reference to sectoral interdependence.[5] There are some important issues that may be discussed better within a comprehensive framework, but the choice of formulation still is determined by the purpose of the discussion.[6] The present framework emphasizes an explicit sectoral formulation, not for its own sake, but as a framework for empirical analysis. The purpose here is to formulate a model that can be given empirical content and that generates results which can be confronted with the actual data. Such a model makes it possible to

[5]Cf. T. W. Schultz, *Economic Growth and Agriculture* (New York: McGraw-Hill, 1968).

[6]Cf. John W. Mellor, *The New Economics of Growth: A Strategy for India and the Developing World* (Ithaca and London: Cornell University Press, 1976).

provide a quantitative assessment of the effects of applying various policy instruments. Again, there is nothing new in this endeavor in general, although it is less common in the framework of growth analysis.[7]

The desirability of having a framework that can be confronted with the data led to replacing the neoclassical model with what is considered to be a more realistic, and therefore more productive, formulation in which the role of resource allocation is an economically endogenous variable. In this formulation, the rates and the directions of changes of variables in the economy are not determined solely by exogenous factors.

It appears that the end product may offer a convenient framework for analyzing substantive issues related generally to sectoral growth and specifically to agricultural growth. It should also prove useful in organizing and integrating research because it brings together various subjects such as production, consumption, and sectoral and functional income distributions. Of course, the present formulation is just an instrument in the analysis and can be modified according to needs.

## Methodology

Applying the model requires fitting it to the data. The system is a dynamic one, and the choice of parameter values affects the various variables, not only at a given point in time, but also along the growth path. Any selection of a single criterion for judging the choice of the empirical values for the parameters in question is at best arbitrary. Thus, there can be various sets of parameters that will give reasonable fit. Furthermore, there is no need to assume or require that the parameters remain constant throughout the period of application. In the method used here for computation, it may be relatively simple to allow the parameters to change with time or with the values of some of the variables of the model. Thus, though we deal with a variable coefficients model, we have not pursued the possibilities of varying coefficients very far, except that we have a different set of values for the prewar and postwar analyses.

Basically, the question raised here is the question of identification, which, in the present framework, may be more acute than in the standard, constant coefficient model. However, it should be kept in mind that this problem is not peculiar to this particular model; it is of a rather general nature and faces every researcher who tries to infer from data, regardless of whether he uses a formal model to do so.

## Substance

The emphasis in this work has been on the nature and consequences of resource allocation in the process of growth. More profoundly, there is an attempt to view correctly the process of economic dynamics in which the economy is ever adjusting to changing conditions at rates that are considered to be economically endogenous variables. Such a view is applicable to many subjects in economics. Our objective has

---

[7]There are some possible exceptions. Cf. A. C. Kelly, J. G. Williamson, and R. Cheetham *Dualistic Economic Development* (Chicago: University of Chicago Press, 1972).

been to apply it to the study of agricultural growth. In so doing, we have formulated the growth process. Naturally, such a formulation does not cover exhaustively all phenomena that are, or may be, pertinent to growth. The work can, and should, be broadened so as to also include the study of those phenomena. Such a study will require modifications in the formulations of the economy, but it can be conducted within the framework suggested here and thus lead to confrontation with the data.

Growth models generally view growth as primarily supply-determined. The question has been posed whether this view is justified and whether growth should not also be viewed as demand-determined.[8] Stated differently, the question is whether there is really a dichotomy between short-run and long-run macro models. Our formulation has gone part way in incorporating demand in the analysis. Yet long-run phenomena, such as unemployment in what is called labor surplus economies, require some further consideration. This question is related to the scope of the analysis and the extent to which the nonagricultural sector can be made to grow much faster.

Another aspect of the role of demand appears when the economy has access to foreign markets. The extension of the formulation to include foreign trade may have an important effect on sectoral development; the nature of the effect, of course, depends on whether the country is food-exporting or food-importing. In addition to the immediate effect on the sectors, there is an effect on domestic investment, depending on the direction or sign of foreign savings. Because the size and sign of foreign savings depends on world price variations, the inclusion of foreign trade brings in possible fluctuations that may have an important effect on the countries in question.[9]

The present formulation assumes that decisions are made freely by individuals in the system. To take a step toward reality, the model should be extended to include government and the various effects that it may have on the system.[10] Such an extension will provide policy instruments intended to affect the development of the system and at the same time will provide the framework for quantitative evaluation of the effectiveness of these instruments.

Along with foreign trade, there are many other sources that may introduce fluctuations into the economy. One source is particularly worth mentioning: the dependence of agriculture on the weather. Granted that there are fluctuations that cannot be avoided, the question is whether such fluctuations have any effect on growth in general and sectoral growth in particular or whether growth depends only on average performance.

---

[8] I am indebted to John Mellor for pointing this out to me.

[9] The experience of the seventies provided plenty of evidence on this subject. Cf. D. G. Johnson, *World of Agriculture in Disarray* (London: Macmillan, 1973).

[10] This is not the place to list the various effects that government may have on system. Yet it should be mentioned that some of the agricultural outflow of savings was brought about in Japan, as well as in other countries, through the tax system.

# 2

## MIGRATION OUT OF AGRICULTURE: EMPIRICAL ANALYSIS

It is well known that economic growth leads to changes in the industrial composition of the economy, and these changes, in turn, affect the growth rate of the economy.[11] The aspect of immediate interest to this study is the declining importance of agriculture.

A change in industrial composition results from a change in resource allocation, including that of labor, leading to "occupational migration." Part of this phenomenon involves actual occupational changes by workers, and part involves different occupational choices by new employees. The relative importance of these two situations depends largely on the rate at which the economy changes its industrial composition compared with the natural rate of population (labor force) growth. Regardless of which force is dominant at any point in time, existing employment opportunities dictate the allocation of workers among different occupations: the more attractive the new opportunities are, the more people will pursue them. It is this premise, almost axiomatic to economists, that this study purports to measure.

Occupational mobility is closely related to geographical mobility—at least when the migration is away from agriculture. The two measures are not identical, however, and need not be so. The general subject of migration is not new; a recent, partial survey listed 250 references on the subject.[12] More specifically, there is a considerable body of literature dealing with the empirical aspects of migration away from the farm. This literature deals largely with the American experience.[13]

---

[11]The seminal work of Simon Kuznets has quantified various aspects of this process; see, for example, *Modern Economic Growth, Rate Structure and Spread* (New Haven: Yale University Press, 1966) and *Economic Growth of Nations: Total Output and Production Structure* (Cambridge. Harvard University Press, 1971).

[12]M. J. Greenwood, "Research on Internal Migration in the United States: A Survey," *Journal of Economic Literature* 13 (1975): 397-433.

[13]See, for example, C. E. Bishop, "Economic Aspects of Changes in Farm Labor Force," in *Labor Mobility and Population in Agriculture* (Ames: Iowa University Press, 1961); G. K. Bowles, *Farm Population—Net Migration from the Rural-Farm Population, 1940-1950*, U.S. Department of Agriculture, Agricultural Marketing Service, Statistical Bulletin no. 176 (Washington, D.C., June 1956); D. E. Hathaway, "Migration from Agriculture: The Historical Record and its Meaning," *American Economic Review* 50 (1960): 379-91, and "Improving the Search for Employment" (Paper delivered to the Conference on Creating Opportunities for Tomorrow, 1968); W. E. Johnston, "Projecting Occupational Supply Response," in *Study of U.S. Agricultural Adjustments*, ed. G. S. Tolley (Raleigh: North Carolina State University, n.d.); W. E. Johnston and G. S. Tolley, "The Supply of Farm Operators," *Econometrica* 36 (1968): 365-82; and L. A. Sjaastad, "Occupational Structure and Migration Patterns," in *Labor Mobility and Population in Agriculture* (Ames: Iowa University Press, 1961).

In recent years, farm migration has come to a halt in the United States.[14] The process has also ended in some other mature economies, and the lessons to be drawn from their experiences have become particularly important as interest in economic development grows. An important role in development has been attributed to migration out of the traditional sector—usually agriculture—into the modern sector.[15] The emphasis placed on surplus labor in this process immediately raises the question of how the labor market mechanism operates in the traditional sector—specifically, whether labor in that sector is at all productive at the margin. Some interesting evidence has been produced that the marginal productivity of such labor is, indeed, positive.[16]

Sectoral migration is of prime importance and bears important policy implications, as well as an analytic role. The analysis of sectoral migration is associated with the attempt to model and quantify the causal relationships that are involved in the process of growth and development. An interest in these relationships prompted the present study.

In spite of the importance of the subject, however, there does not seem to be any empirical sectoral migration equation at the macro level. The reason for this void is not clear. It is possible that aggregation blurs the data and makes it difficult to obtain acceptable estimates. Whether or not this is the reason, it is clear that if such an equation is important, the data should reveal it, and there must be a way to estimate it.

It has been suspected that the lack of empirical macro equations reflects lack of success rather than lack of attempts.[17] A good reason for the lack of success may be the use of data with little spread in the interesting variables and considerable spread in other variables. For this reason, the present study uses data with large spread in the important variables—that is, country cross-section data.[18]

The following section deals with the formulation of the problem; it relies on existing and known concepts, and it concentrates on bringing these concepts together for the purpose at hand. The next section presents the empirical results. A few concluding remarks appear in the final section. The data sources are discussed in Appendix A.

---

[14]E. G. Schuh, "The New Macroeconomics of Agriculture," *American Journal of Agricultural Economics* 58 (1976): 802-11.

[15]See W. A. Lewis, *The Theory of Economic Growth* (London: Allen and Unwin, 1955); G. Ranis and J. C. H. Fei, "A Theory of Economic Development," *American Economic Review* 51 (1961): 533-65; and D. W. Jorgenson, "The Development of a Dual Economy," *Economic Journal* 71 (1961): 309-34.

[16]See T. W. Schultz, *Transforming Traditional Agriculture* (New Haven: Yale University Press, 1964), chapter 4.

[17]For partial results, see Sjaastad, "Occupational Structure," and Bishop, "Economic Aspects."

[18]The use of information based on country cross sections is not new. For instance, a great many of Simon Kuznets' findings are based on this type of data. There are also known works using regression analysis based on such data; for example, in consumption functions: H. S. Houthakker, "An International Comparison of Household Expenditure Patterns: Commemorating the Centenary of Engel's Law," *Econometrica* 25 (1957): 532-51; in production functions: K. J. Arrow, H. B. Chenery, B. S. Minhas, and R. M. Solow, "Capital Labor Substitution and Economic Efficiency," *Review of Economics and Statistics* 43 (1961): 225-50; and in development: H. B. Chenery and M. Syrquin, *Patterns of Development, 1950-1970* (London: Oxford University Press, 1975).

## Model Formulation

The background for our model is a neoclassical, two-sector economy, consisting of an agricultural sector and a nonagricultural sector.[19] Appropriately specified, such an economy has a competitive short-run equilibrium in which wage rates of the homogeneous labor input are equal in the two sectors. Changing the exogenous variables (which need not be specified here) results in a new short-run equilibrium. It is thus possible to obtain a sequence of short-run equilibrium solutions that yield, among other things, the labor allocation and wage rates. Two aspects of this process are worth emphasizing: first, no calendar time enters the formulation; and second, wage rates are always the same across sectors. In this context, migration simply reflects a change in the competitive allocation of labor.

These two aspects limit the empirical application of the model. The two points are not independent. Labor mobility is hindered by friction, and as a result, low rate of mobility is insufficient to lead to wage equality; consequently, the data show wage differentials across sectors. Specifically, in terms of our dichotomy, agriculture is the net supplier of labor, and—because of the friction on mobility—the wage rates in agriculture are lower than in the nonagricultural sector. It is possible to analyze the behavior of the economy under the constraint of wage differentials.[20] In order to endogenize the wage differentials, however, it is necessary to take explicit account of the determinants of the rate of migration. To do this, we have formulated a migration equation.

The basic premise of the equation is that migration is motivated by an income differential, which we denote by $\delta$. Migration is also affected by exogenous variables $(z)$ to be specified later. The premise, then, is that

$$M = f(\delta, z), \quad f_\delta > 0, \tag{2.1}$$

where

$M$ = migration from the agricultural to the nonagricultural sector per unit of time, and

$f_\delta$ = partial derivative with respect to $\delta$.

Equation (2.1) takes no account of the size of the agricultural labor force ($L_1$), which constitutes the source of labor supply. For any given value of the argument of (2.1) migration should increase with $L_1$.[21] In addition, migration depends on prospects in the nonagricultural sector, and those can be measured by $L_2$, the nonagricultural

[19] Cf. Mundlak and Mosenson, "Two-Sector Model," pp. 227-58.

[20] Cf. Z. Tropp and Y. Mundlak, *Distortion in the Factor Market and the Short Run Equilibrium,*" Discussion Paper 454, Harvard Institute of Economic Research (Cambridge, 1976).

[21] P. Zarembka, "Labor Migration and Urban Unemployment: Comment," *American Economic Review* 60 (1960): 184-86; and H. S. Houthakker, "Disproportional Growth and the Intersectoral Distribution of Income," in *Relevance and Precision, from Quantitative Analysis to Economic Policy; Essays in Honor of Pieter de Wolff*, eds. J. S. Cramer, A. Heertje, and P. E. Venekamp (Alphen aan den Rijn: Samsom and New York: North Holland, 1976).

labor force. A given rate of migration will be absorbed more easily with a larger absorbing sector.

The introduction of $L_1$ and $L_2$ into the migration equation should be done in such a way as to maintain a "constant-returns-to-scale" property with respect to the size of the country. That is, for any given $\delta$ and $z$, doubling the size of the country, and therefore the labor force in the two sectors, should double the migration. When (2.1) is expanded to include the labor force variables, then

$$M = f(\delta, z)\, L_1^{1-\beta}\, L_2^{\beta}, \quad 0 < \beta < 1. \tag{2.2}$$

The equation can also be written in terms of migration as a proportion of the agricultural labor force.

$$m = f(\delta, z)\, r^{\beta}, \tag{2.3}$$

where

$m = M/L_1$, and

$r = L_2/L_1$.

In addition to the existing composition of the labor force, migration is affected by the rate of growth of the labor force, $n$. Adding this factor to equation (2.3), then

$$m = f(\delta, z) r^{\beta_2} (1+n)^{\beta_3}. \tag{2.4}$$

The introduction of (2.4) to a two-sector model makes it possible to "close" the model and to trace its equilibrium path, which also determines the values for $\delta$ and $r$, as a function of time and the exogenous variables in question.[22] However, statistically $\delta$ and $r$ are predetermined at any point in time, and (2.4) basically can be estimated by a single equation method.

Definition of the income variable depends on the nature of the decision made by the individual. If the nonfarm opportunities are close to, or in, the rural areas and there is a continuous two-way shift between the two sectors, wage rates may be appropriate for measuring income differentials. If, however, the decision involves changing occupation and possibly residence as well, then the relevant variable should be the discounted stream of income over the life horizon.[23] To allow for uncertainties about obtaining a job in the new sector, Todaro suggested that earnings be weighted by their probabilities.[24] Because the present analysis is concerned with

[22]Houthakker, "Disproportional Growth," and J. R. Harris and M. P. Todaro, "Migration, Unemployment and Development: A Two-Sector Analysis," *American Economic Review* 60 (1970): 379-91.

[23]L. A. Sjaastad, "The Cost and Returns of Human Migration," *Journal of Political Economy*, Supplement, 70 (1962): 80-93.

[24]M. P. Todaro, "A Model of Labor Migration and Urban Unemployment in Less Developed Countries," *American Economic Review* 59 (1969): 138-48.

long-run structural changes, expected income, rather than wage rates, is the more appropriate variable.

If $V_1(t)$ and $V_2(t)$ are the expected lifetime earnings in sectors 1 and 2 respectively, and $C(t)$ is the cost of migration, then the assumption is that a person will tend to migrate as long as

$$V_2(t) - V_1(t) > C(t). \tag{2.5}$$

Using this formulation, it is possible to justify the monotonicity of migration with respect to $\delta$. Individuals are not homogeneous in their expected earnings and costs of migration, but the larger the gap between the two sectors, the more individuals will find that the difference in earnings justifies the change.

This argument may seem somewhat inconsistent with the assumption of homogeneous labor, which is made in simple models. However, one attribute, age, enters here which does not violate the assumption of homogeneous labor. The integrals which result in $V_1(t)$ and $V_2(t)$ depend on the planning horizon, $\tau$. It is possible that a given difference in the rates of earning may meet the condition of (2.5) for a large value of $\tau$ but not for small values. Furthermore, the cost of migration by itself is likely to decrease as $\tau$ increases.[25] For this reason, we may expect the younger age groups to be more than proportionately represented among migrants.[26]

The expected income variables are not directly measurable. In aggregate analysis, it is possible to approximate them by using the average per-capita production originating in the respective sectors and allowing for growth. Strictly speaking, the discussion calls for a measure based on labor income; but there is no need to be so restrictive because it is not quite clear that people exclude nonwage income from their life expectations.

A question that has been dealt with in various works is the extent to which unemployment in the nonagricultural sector affects migration. The essence of Todaro's formulation has been to show that migration is compatible with unemployment in the receiving sector. The result is obtained by weighting the future stream of income by the probabilities of being employed. The probabilities are approximated by the proportion of employment to total labor force in the receiving sector. This approach offers one way to handle the effect of unemployment empirically. Consistent treatment, however, calls for a similar allowance for employment contingencies in agriculture; for that matter, there is a tendency to disregard unemployment in agriculture, which is questionable in itself. However, in agriculture, there is additional uncertainty with respect to natural factors such as floods and droughts. It would be desirable to account for some of these nonwage considerations that affect migration.

To formulate (2.4) more explicitly for empirical study, the equation is assumed to be

---

[25]Younger persons, whose planning horizons are long, are likely to have a lower cost of migration. Cf. A. Schwartz, "Migration, Age and Education," *Journal of Political Economy* 84 (1976): 701-19.

[26]For empirical evidence on this question, see Bowles, *Farm Population;* Hathaway, "Migration from Agriculture"; Kuznets, *Modern Economic Growth*, p. 125; Johnston, "Projecting Occupational Supply," p. 146.

of the Cobb-Douglas form. To allow for zero migration, the variable $(\delta - c_1)$ is used instead of $\delta$, where $c_1$ is some constant. Thus,

$$m = e^{\beta_0}(\delta - c_1)^{\beta_1} r^{\beta_2}(1 + n)^{\beta_3} z^{\beta_4}, \tag{2.6}$$

and when $\delta = c_1$, then $m = 0$. By definition, a natural value for $c_1$ is 1; that is, an ideal measure of the income differential, $(\delta - c_1)$, should lead to no migration if the income ratio is 1. However, it is not quite clear that a reported income series fulfills such a requirement. First, there is the uncertainty referred to above. In addition, favorable arguments have been advanced for the quality of farm life.

The uncertainty argument should lead to a value of $c_1$ that is smaller or larger than 1, depending on whether uncertainty is larger or smaller in the receiving sector as compared with the sector of origin and on individual attitudes toward risk.[27] If the quality of farm life is more attractive than the "city lights," the value of $c_1$ would tend to be larger than 1; that is, it would require a premium to get people out of agriculture.

To some extent, the relative importance of these two considerations depends on the level of development. The quality of life argument is perhaps more important in wealthier economies, where it might be possible to have negative migration. To allow for negative migration, a constant, $c_0$, can be added to the left-hand side of (2.6). Thus, the basic equation that is actually estimated can be written as

$$\ln (m+c_0) = \beta_0 + \beta_1 \ln (\delta - c_1) + \beta_2 \ln r + \beta_3 \ln (1+n) + \beta_4 \ln z + u, \tag{2.7}$$

where $u$ is a disturbance variable, which we assume to possess the standard properties. It should be noted that the value of $c_1$ which corresponds to zero migration obviously must be related to the value of $c_0$.

The exogenous variables, represented by $z$, have not been specified thus far. The working hypothesis was that education contributes to mobility.[28] As a measure of education, we used the proportion of secondary school enrollment to the secondary-school-age population. A more appropriate variable would have been the level of education in the migrating sector, but such data were unavailable. The second variable represented in $z$ is age. Each of two measures was used: (1) persons aged 15-29 as a proportion of total population, and (2) persons aged 30-39 as a proportion of total population.

## Empirical Results

Data on 72 countries for the years 1960 and 1970 constitute the basis for the cross-section analysis. The data and their sources are discussed in Appendix A. The

[27] The variable $c_1$ could be considered to depend on the risk and other variables as well. This formulation is not explored here because the sample data are not sufficiently rich to allow empirical analysis.

[28] M. Gisser, "Schooling and the Farm Problem," *Econometrica* 33 (1965): 582-92.

labor force data are the economically active population in the farm and nonfarm sectors. The simple average annual migration over the decade was obtained from these data by comparing the actual labor force with that which would have been realized if there had been no migration. The resulting formula is

$$M = 1/t\,(L_t)\left[\frac{1+n_1}{1+n}\,\ell_{10}-\ell_{1t}\right] \tag{2.8}$$

where

$M$ = simple average annual migration,

$n_1$ = decade rate of growth of the agricultural labor force,

$n$ = decade rate of growth of the total labor force,

$L_t$ = total labor force in year $t$,

$\ell_{10}$ = proportion of sector 1 in the total labor force in the base year, and

$\ell_{1t}$ = proportion of sector 1 in the total labor force in year $t$.

For some countries, the data are for years other than 1960 and 1970; in these cases, simple annual average migration is calculated by dividing migration during the relevant period by $t$, the number of years between the two surveys.

There is no series of sectoral labor force growth rates covering all the countries in question, so we computed two migration series. In series 1 ($m_1$), we assumed growth rates are equal in the two sectors; series ($M_2$) assumes they are different. The difference in labor force growth rates between the rural and urban sector may be very high, as much as 3 to 1.[29] However, it is unlikely that this ratio is a constant; it is more likely that it declines in the process of development. For series 2, then, we assumed that (1) at one limit, $\ell_1 = 1$ and $n_2 = \frac{1}{4}\,n_1$, where $n_2$ is the labor force growth rate for the nonfarm labor force; (2) at the other limit, $\ell_1 = 0$ and $n_2 = n_1$; and (3) intermediate values are given by linear interpolation. Using $n = \ell_1 n_1 + \ell_2 n_2$, this assumption leads to

$$n = n/(1 - \tfrac{1}{4}\,\ell_1\ell_2). \tag{2.9}$$

The $M_2$ series was computed by substituting (2.9) in (2.8). As expected, the two series are highly correlated and yield basically similar results.

Because the statistics used are for the economically active, rather than the total, population, we dealt primarily with occupational, rather than geographical, migration. The two are different, though related, concepts, but occupational migration is of more immediate interest in the present context.

The income variable was measured by the ratio of the average productivity in sector 2 to that in 1, where the average productivity was obtained by dividing the gross domestic product (GDP) originating in each sector by the economically active population in that sector. The labor force data include the unemployed, and therefore

[29]Kuznets, *Modern Economic Growth*, p. 116.

average productivity was adjusted for the probability of obtaining employment in Todaro's sense.

## Estimates Using Equal Growth Rates

The main results for the first migration series are summarized in Table 1. The regression was obtained by ordinary least squares (OLS), with some iteration on $c_0$ and $c_1$.[30] The first five regressions in the table report some interesting results of this iteration. All the variables proved to be empirically pertinent and to possess the right sign; as expected, the coefficient of $r$ is a positive fraction. There was no particular prior expectation about the order of magnitude of the coefficients.

Considering the fact that the dependent variable is migration as a proportion of the agricultural labor force, rather than total migration, the fit is rather good. The iteration on the c's slightly affects the fit and the $t$-ratios.[31] Somewhat better results were obtained for $c_0 = 0.012$ and $c_1 = 0.5$.[32] When the values of the c's change, the coefficients change correspondingly.

Several variables that were tried did not prove statistically significant. The model assumes constant returns to scale, and this was tested empirically by adding the nonagricultural labor force as another variable. The resulting $t$-ratio for the coefficient of this variable was very low, and the assumption remained unchallenged. An attempt to add age variables did not yield any significant change, perhaps because of the small spread in the data. Finally, the rate of expansion of the nonagricultural sector was introduced to measure the expansion in demand for migratory labor; it also was not significant. Explicit treatment of an unemployment variable was not tried because of lack of data.

Considering the nature of the data, statistical difficulties are likely, and the extent to which the usual optimal statistical properties can be attributed to the results is questionable. Without attempting to minimize this point, a practical check could be applied. Because the values used for $r$, $\delta$, and education are for 1960, it was possible to use the 1970 values as instrumental variables. For the same reasons that the data are suspect, one may assume that existing errors are unlikely to be highly correlated during the period of a decade.

The result of the instrumental variable analysis is given in line 8 of Table 1 for the case of $c_0 = c_1 = 0$. The major change is that the education variable disappears. Because this variable is positively correlated with $r$, the coefficient of $r$ increases slightly. Otherwise, results are surprisingly close to the OLS, reflecting the wide

---

[30]This was done to avoid nonlinear estimation at this stage.

[31]Strictly speaking, the improvement in fit is not a very meaningful criterion here since the dependent variable is changing as $c_0$ changes. Expanding $\ell n(m + c)$ as a Taylor's series around m yields

$$\ell n(m+c) - \ell n(m) = \frac{c}{m} - \frac{1}{2}\left(\frac{c}{m}\right)^2 + \frac{1}{3}\left(\frac{c}{m}\right)^3 + \ldots$$

The fit serves as a good criterion when the right-hand side is negligible.

[32]A value of $c_1 = 1$ was not used in the iteration because there were some observations with $\delta$ between 0.9 and 1.0.

## Table 1—Estimates of migration equation ($M_1$), 70 countries, 1960-70

| Regression Number[a] | $c_0$ | $c_1$ | $b_0$ | $\delta - c_1$ | $r$ | $ed$ | $1 + n$ | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | −4.559 | 0.522 | 0.489 | 0.197 | 8.623 | .580 |
| | | | (15.9) | (3.4) | (4.5) | (1.9) | (2.6) | |
| 2 | 0 | 0.9 | −4.115 | 0.244 | 0.449 | 0.204 | 9.627 | .565 |
| | | | (18.0) | (3.0) | (4.2) | (2.0) | (2.9) | |
| 3 | 0 | 0.5 | −4.362 | 0.427 | 0.493 | 0.195 | 8.943 | .581 |
| | | | (17.4) | (3.4) | (4.5) | (1.9) | (2.7) | |
| 4 | 0.012 | 0 | −3.708 | 0.267 | 0.263 | 0.108 | 4.622 | .596 |
| | | | (24.4) | (3.3) | (4.6) | (2.0) | (2.7) | |
| 5 | 0.012 | 0.5 | −3.609 | 0.220 | 0.266 | 0.107 | 4.781 | .598 |
| | | | (27.1) | (3.3) | (4.6) | (2.0) | (2.8) | |
| 6 (i) | 0 | 0 | −4.761 | 0.436 | 0.540 | 0.142 | 9.605 | .619 |
| | | | (15.5) | (2.9) | (4.7) | (1.2) | (3.1) | |
| 7 (i) | 0 | 0.9 | −4.533 | 0.307 | 0.571 | 0.115 | 9.867 | .623 |
| | | | (18.0) | (3.1) | (4.9) | ( .9) | (3.2) | |
| 8 (ii) | 0 | 0 | −4.785 | 0.467 | 0.620 | 0.062 | 9.717 | .559 |
| | | | (16.6) | (2.1) | (3.9) | ( .4) | (2.9) | |

Note: Numbers in parentheses indicate the absolute values of the corresponding *t-ratios*.

[a]Estimated by OLS: regressions 1-5 use beginning-of-the-period values for the explanatory variables; regressions 6-8 use the following methods.
i = explanatory variables averaged for the beginning and end of period
ii = estimated by instrumental variables

spread in the country cross-section data, which perhaps dominates any other disturbances in the data. The analogy to cross-section analysis of Engel's curves is immediate.

The same factors are also reflected in regressions 6 and 7, which are obtained by averaging the explanatory variables over the period (except for $n + 1$). *Averaging serves two purposes: first, it reduces observation errors; second, it avoids the possibility that the indicators for the beginning of the decade are less effective toward its end. Averaging somewhat improved the fit and reduced the significance of the education variable, but in a qualitative sense it left the result unchanged.*

*Estimates Using Two Observations per Country*

*The availability of repeated observations in a cross-section analysis adds valuable information in examining the sensitivity of the results to systematic variations not captured by the explanatory variables. Data for another decade, 1950 to 1960, exist for some OECD countries.*[33] The analysis was repeated for these countries, resulting in observations for each country. Because information on the education variable was not readily available for the first decade, it was excluded from the analysis. Its omission is not likely to be serious, particularly because the spread of this variable in the subsample is smaller than that observed in the original sample.

The results of this analysis are reported in Table 2. The regressions are based on the whole subsample, 34 observations. In each of the regressions, the hypothesis of a "decade effect" was tested and found to be not significantly different from zero, with the $t$-ratios varying around 1 to 1.3; so we concluded that the explanatory variables capture the important changes that took place over time. Because there were only two observations per country, we did not test the existence of a country effect. A comparison of the results with those of Table 1 shows close similarities, which suggests that if country effects exist, they may not have a very important influence on the cross-section estimates.

Results for the $M_2$ Series

The results obtained with the $M_2$ migration series are reported in Table 3. The first part of the table presents the results for the sample as a whole, and the second part presents the results of the OECD countries. In both cases, the fit improved somewhat compared with that for the $M_1$ series. The results for the more mature economies, which are also assumed to have better statistics, are very similar to those obtained for the sample as a whole. Furthermore, there is no serious "decade effect." The results tend to confirm those found for the two $M_1$ series.

Effect of Changes in the $c$'s

For the $M_2$ series, the values of $c_1$ that seem to work better are 0.8 for the sample as a

[33]This group of 17 countries is hereafter referred to as the OECD sample.

## Table 2—Estimates of migration equation ($M_1$), OECD countries, 1950-70

| Regression Number[a] | $c_0$ | $c_1$ | $b_0$ | $\delta \cdot c_1$ | $r$ | $1 + n$ | $R^2$ |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | −4.232 | .390 | .346 | 11.704 | .397 |
| | | | (14.7) | (1.4) | (3.2) | (1.5) | |
| 2 | 0 | .85 | −3.977 | .232 | .372 | 10.863 | .431 |
| | | | (33.0) | (2.0) | (3.8) | (1.4) | |
| 3 | .012 | 0 | −3.621 | .259 | .219 | 8.910 | .429 |
| | | | (20.6) | (1.5) | 3.3) | (1.8) | |
| 4 | .012 | .85 | −3.453 | .156 | .238 | 8.326 | .469 |
| | | | (47.1) | (2.2) | (4.0) | (1.8) | |
| 5 | .5 | .85 | −0.653 | .012 | .017 | .757 | .513 |
| | | | (127.9) | (2.4) | (4.1) | (2.4) | |

[a]Each of the 17 countries had two observations; beginning-of-decade values were used for the explanatory variables; equations were estimated by OLS.

## Table 3—Estimates of migration equation ($M_2$)

| Regression Number | $c_0$ | $c_1$ | $b_0$ | $\delta - c_1$ | $r$ | $ed$ | $1 + n$ | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| | | | 70 countries, 1960-70 | | | | | |
| 1 | 0 | 0 | −4.304 | .320 | .414 | .136 | 13.191 | .630 |
| | | | (19.4) | (2.7) | (4.9) | (1.7) | (5.2) | |
| 2 | 0 | .8 | −4.122 | .235 | .431 | .132 | 13.553 | .643 |
| | | | (23.2) | (3.2) | (5.2) | (1.7) | (5.5) | |
| 3 | 0 | .9 | −4.064 | .188 | .416 | .136 | 13.753 | .640 |
| | | | (23.7) | (3.1) | (5.2) | (1.8) | (5.5) | |
| | | | OECD countries, 1950—1970 | | | | | |
| 1 | 0 | 0 | −4.229 | .394 | .324 | | 17.61 | .447 |
| | | | (15.5) | (1.5) | (3.2) | | (2.3) | |
| 2 | 0 | .85 | −3.967 | .226 | .346 | | 16.95 | .477 |
| | | | (3.45) | (2.0) | (3.7) | | (2.3) | |
| 3 | .012 | .85 | −3.447 | .151 | .224 | | 12.03 | .508 |
| | | | (47.8) | (2.2) | (3.8) | | (2.7) | |
| 4 | .5 | .85 | −0.652 | .012 | .016 | | 1.045 | .549 |
| | | | (126.1) | (2.4) | (3.9) | | (3.2) | |

whole and 0.85 for the OECD sample. There was some improvement in fit by setting values of $c_0$ at values other than zero. For the $M_1$ series using the OECD sample, the iteration over $c_1$ gave the best fit at $c_1 = 0.85$. The iteration on $c_0$ showed an improvement in fit, although at a slow rate, up to about $c_0 = 0.5$.

What effect does this improvement have on the results? Particularly, what is the value of $\delta$ for which the migration would be zero? When $c_0 = 0$, the answer is $c_1$, but in general $m = 0$ implies, in terms of the present framework and assuming $u = 0$, that

$$\delta(m = 0) = c_1 + \exp\frac{1}{\beta_1}\left(\ell n c_0 - \beta_0 - \beta_2 \ell n r - \beta_3 \ell n(1+n) - \beta_4 \ell n\ ed\right). \qquad (2.10)$$

Substituting estimates for the coefficients in question, the values for $\delta$ in (2.10) were estimated for the OECD sample for the cases of $c_0 \neq 0$ in both migration series.

For the great majority of countries, the second term on the right-hand side of (2.10) added little to $c_1$. The results for the mean points of the sample are given in Table 4. It is clear that as $c_0$ changes, compensating changes in the regression coefficients leave the resulting values of $\hat{\delta}(m = 0)$ largely unchanged.

**Table 4—Values of $\hat{\delta}$ ($m$ = 0) for the OECD countries**

| Migration Series[a] | $C_0$ | $C_1$ | $\hat{\delta}$ ($m$ = 0) |
|---|---|---|---|
| $M_1$ | 0.012 | 0.850 | 0.8504 |
| $M_1$ | 0.5 | 0.850 | 0.8560 |
| $M_2$ | 0.012 | 0.850 | 0.8503 |
| $M_2$ | 0.5 | 0.850 | 0.8550 |

[a]Computed from (2.10) for the given values of $c_0$, $c_1$, and the corresponding regression coefficients.

Because migration for most countries was positive, the value of $m = 0$ which we selected to check the sensitivity of the system to changes in $c_0$ is on the margin of the observations. Thus stronger results are expected for evaluations within the domain of observations. It is interesting that the value of $c_1$ obtained in this study is close to 1. In fact, the changes in the fit in the neighborhood of $c_1 = 0.8$ were not drastic; so we cannot reject the value of 1. This does not, of course, settle the refined points of which variable should be used for measuring income differentials (or for that matter utility differentials), but it does indicate that the data used are indeed pertinent and give instructive results. Future studies may examine whether this property is shared by other measures of income differentials, such as wages. This finding, together with the robustness of the result to the instrumental variable estimation, indicates that strong empirical findings would be necessary to make other results more acceptable.

## Summary and Conclusions

It has been postulated that the annual migration rate away from agriculture is determined by the income differential between the two sectors, the composition of the labor force, the natural growth rate of the labor force, and some other related

variables. A migration function was formulated that took the role of each of these variables into account. The function was fitted to data on 70 countries for the decade 1960 to 1970 (or thereabout) as well as on the 17 OECD countries for two decades, 1950 to 1960 and 1960 to 1970.

The selected variables explain the intercountry differences in the rate of migration very well. Furthermore, for the subsample of the OECD countries, the results did not reveal a "decade effect," nor were there any important differences between the results obtained for the OECD countries and for the sample as a whole, which includes less developed countries. It appears, therefore, that the economic variables capture a good part of the systematic variations in the rate of migration.

There has been a great deal of discussion—which usually lacks any empirical content—as to how the income differential should be measured. In the present formulation there is a built-in mechanism to find whether the particular variable used to represent income maintains the property that migration stops when the income differential disappears. In the present analysis, the use of average labor productivity to measure income performed well in this respect.

The results indicate that the process of growth or development creates forces that act in opposite directions on migration. With growth, the ratio of the nonagricultural to agricultural labor forces increases, and that affects the rate of migration positively. At the same time, the growth process leads to a decline in the income differential, which in turn slows down migration.[34] If the rate of population growth also declines with economic growth, migration slows down. When education is statistically significant at all, it speeds up migration. The effect of age on migration, which has been significant in microstudies, was not detected here, probably because the data lacked sufficient variation.

Thus, the qualitative results of this study are in line with economic thinking. It is more difficult to evaluate the quantitative results because alternative estimates are lacking. If we had to choose among the various regressions, we would probably suggest regression 2 or 3 in Table 2.

---

[34] ". . . the intersectoral difference in product per worker between the agricultural and other sectors narrows steadily as we move from the low to the high per-capita product ratios." (Kuznets, *Economic Growth of Nations*, p. 211).

# 3

## OCCUPATIONAL MIGRATION OUT OF AGRICULTURE IN JAPAN

During the twentieth century, Japan has experienced a considerable amount of migration out of agriculture, but the motivation for such migration is by no means self-evident. Ohkawa and Rosovsky attributed this migration to "factors other than income differentials."[35] Their view may reflect the difficulty of distilling the effect of income differentials from time-series data, in which the spread in the systematic component of the income differential is small relative to the spread in its transitory component. This was not much of a problem with country cross-section data, so it seemed possible that the equation developed in Chapter 2 might be relevant in explaining the Japanese experience. One could simply apply this equation (hereinafter called the CCS equation) to the Japanese time-series data and compare the results with the actual experience in migration. This procedure is one step removed from directly estimating a migration equation for Japan from the given data. In this chapter we apply both steps.[36]

The following section applies the country cross-section analysis of Chapter 2 to the postwar Japanese experience. The results are subject to relatively large sampling errors, and, therefore, some alternative formulations are discussed in the subsequent section. The findings are summarized in the final section. A descriptive discussion of the Japanese experience, including a description of the data, the variables used, and their sources can be found in Appendix B.

### The Country Cross-Section Equation and the Japanese Postwar Experience

To test the relevance of the CCS equation to the Japanese experience, we used the second regression in Table 2 to compute migration in the postwar period (1951 to 1972).

Using the actual data for the farm-nonfarm income differential ($\delta$), the labor force ratio ($r$), and the percentage of the labor force that migrated ($m$), a value for $\ln m$ was

---

[35]K. Ohkawa and H. Rosovsky, *Japanese Economic Growth: Trend Acceleration in the Twentieth Century*, (Stanford, Ca.: Stanford University Press, 1973), p. 127.

[36]For differing approaches to this subject, see R. Minami, "Population Migration away from Agriculture in Japan," *Economic Development and Cultural Change* 15 (1967): 183-201, and "The Supply of Farm Labor and the 'Turning Point' in the Japanese Economy," in *Agriculture and Economic Growth: Japan's Experience*, eds. K. Ohkawa *et al.* (Princeton: Princeton University Press, 1970); M. Umemura, "Agriculture and Labor Supply in the Meiji Era," *ibid.*, pp. 175-97; A. R. Tussing, "The Labor Force in Meiji Economic Growth: A quantitative study of Yamanashi Prefecture," *ibid.*, pp. 198-221; Y. Masui, "The Supply Price of Labor: Farm Family Workers," *ibid.*, pp. 222-49; and Ohkawa and Rosovsky, *Japanese Economic Growth*. A remark by Minami in "Population Migration" (p. 193, n. 17) indicates that most of the prior statistical analyses of this subject have dealt with interregional migration rather than intersectoral migration.

obtained for each year and compared with actual migration for those years. The intercepts were determined by the data so as to allow the residuals to average zero. The resulting residuals were subject to first-order serial correlation. The autoregressive scheme was incorporated to yield a new set of estimates of $\ell n\ m$. The results are reported in Table 5 and in Figure 1.

## Table 5—Results of applying the CCS equation to postwar Japanese data

| Type of Data | First-Order Serial Correlation[a] | Estimated Intercept | Country Effect | Sum of Squares | | $\bar{R}^{2b}$ |
|---|---|---|---|---|---|---|
| | | | | Total | Residual | |
| Annual | 0.058 | −3.8289 | 1.16 | 4.453 | 3.442 | 0.227 |
| Moving average | 0 | −3.7558 | 1.25 | 0.619 | 0.284 | 0.541 |
| Moving average (corrected) | 0.519 | −3.7616 | 1.24 | 0.619 | 0.185 | 0.701 |

[a]First-order serial correlation (FOC) coefficients estimated from the data and used in estimating $\ell n\ m$. A two-stage procedure was used. First, the CCS equation was used to compute ln m. Using the computed values, residuals were obtained from which the FOC was calculated. The FOC was used to recalculate $\ln m$ and the residuals. Thus, when FOC = 0, no adjustment was necessary.

[b] $\bar{R}^2 = 1 - \dfrac{\text{residuals sum of squares}}{\text{total sum of squares}}$

Because we apply the equation to data not used in the estimation, the residuals need not be orthogonal to the regression values, and therefore $\bar{R}^2$ is not necessarily equal to the "usual" coefficient of determination, $R^2$.

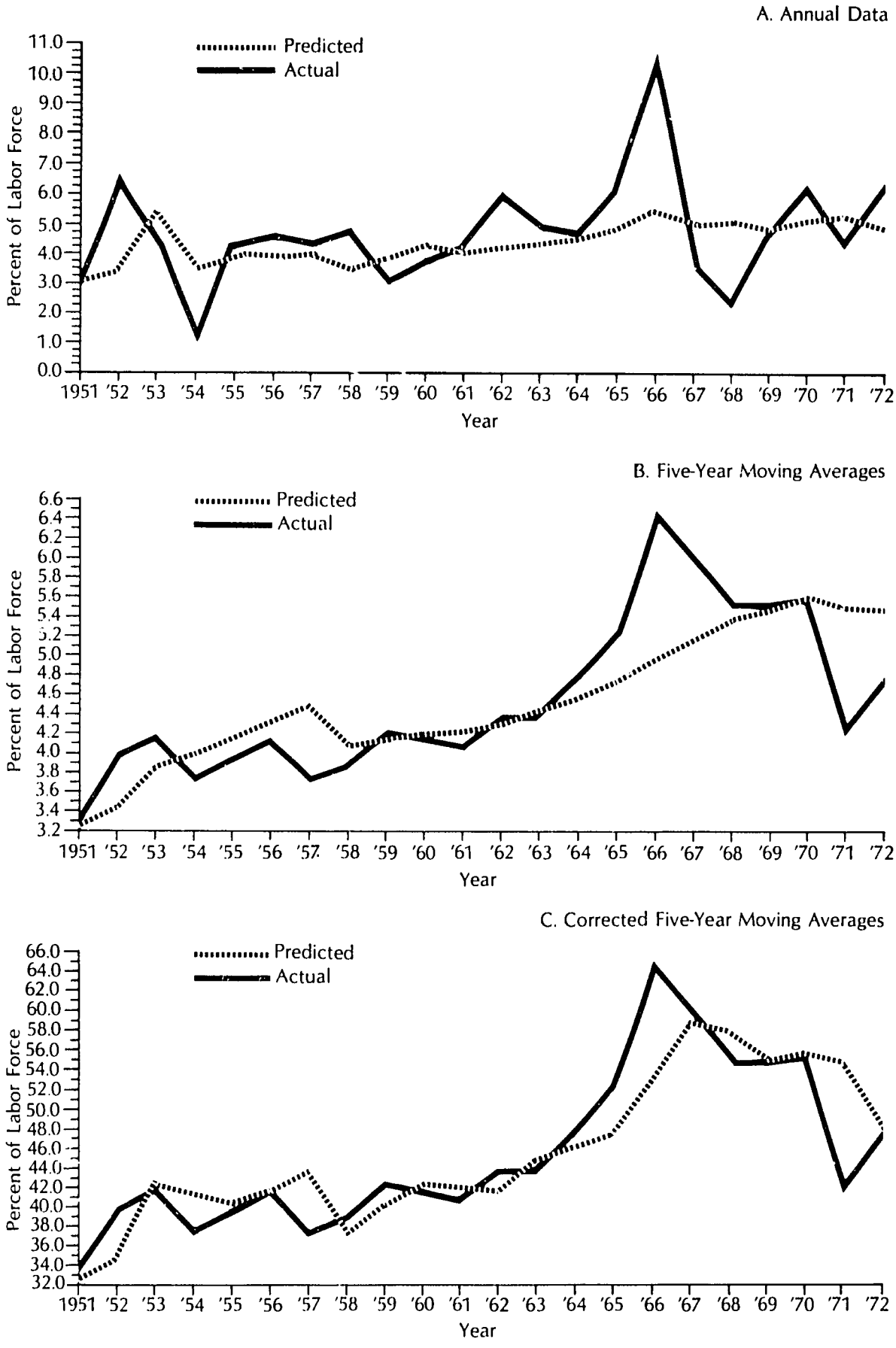
The first line in Table 5 reports the results for the annual data. Because the serial correlation for the annual series was so low, it did not seem necessary to report separately results for the annual regression adjusted for serial correlation. The second column of the table gives the corrected intercept; that is, the intercept given is the actual one, rather than the one determined by the CCS equation. The percentage difference between the two intercepts can be considered the "country effect" of Japan. Column three is the antilog of this difference—1.16—which indicates that the rate of migration in postwar Japan was 16 percent larger than the CCS equation would have predicted based on the values of the explanatory variables. The fourth column indicates that the sum of squares of the dependent variable was 4.453, and the following column indicates that the residual sum of squares was 3.442. The implied "$R^2$-like" measure is

$$\bar{R}^2 = 1 - \frac{3.442}{4.452} = 0.227.$$

The remaining rows of the table are interpreted in a similar way.

A good part of the annual variance in migration (or, to be precise, in $\ell n\ m$) is averaged out by using moving-average data. This explains why various authors have chosen to work with smoothed data. We have made the same choice because our main interest is in the relationships between the systematic components of the variables, not the transitory components. In spite of the smaller variance of the moving-average migration—0.619, instead of 4.453 for the annual data—a larger

**Figure 1. Actual and Predicted Migration, Post World War II Japan**



proportion of it is explained by the CCS equation. The implied values for $\bar{R}^2$ are 0.541 and 0.701 for the uncorrected and corrected series, respectively. It is somewhat remarkable that the CCS equation has this much explanatory power when applied to time-series data.

The results of directly estimating the migration equation using data for postwar Japan are given in Table 6. Line 1 reports unrestricted estimates. The fit is better than that obtained by applying the CCS equation. Part (and only part) of the improvement is due to the elimination of the first-order serial correlation. However, the coefficients of the variables themselves are subject to relatively large sampling errors. This suggests that there is not enough variation in the data to allocate precisely the total effect of each of the variables on migration.

To make sure that farm-nonfarm income differences influence migration at all, a simple regression on the income differential ($\delta$) was estimated; the results are reported on line 2 of Table 6. Line 3 reports the simple regression on the labor force ratio ($r$). The fit is good in both cases, so the difficulty in obtaining significant coefficients in direct estimation must result from the multicollinearity. In this case, it is possible to impose the results obtained by applying the CCS equation, which fits the data well. This is done in three steps: in line 4, only the coefficient of ($\delta - 0.85$) lagged one year was imposed;[37] in line 5, the country cross-section value of the $r$ coefficient was added; and in line 6, the coefficient for the labor force growth rate was included along with the other two.[38] In each of these steps, the drop in $R^2$ is very small, indicating that the restriction imposed by the country cross-section results cannot be rejected by the data. In fact, testing the most extreme hypotheses—the regression in line 6 against that of line 1—gives a relatively low $F$-value. It is therefore concluded that the country cross-section results are not rejected by the time-series data.

In conclusion, the large sampling error (in part due to multicollinearity) results in large confidence regions (or ellipsoids), so the country cross-section results are not rejected. At the same time, we do not reject the null hypothesis with respect to the coefficients of either $\delta$ or $r$. The results for the prewar period gave even larger sampling errors and did not yield significant results. In view of this outcome, it was desirable to explore alternate formulations.

## Alternate Formulations

As an alternate to the CCS equation, we tried to account for the migration in the prewar period in terms of the level of economic activity.[39] This was measured by the

---

[37]Throughout, we use ($\delta - c_1$) rather than $\delta$ alone, and only the value 0.85 is used for $c_1$. This was done in order to allow comparison with the CCS equation.

Lagging ($\delta - 0.85$) one year gave somewhat better fit than ($\delta - 0.85$) for the current year. Hereafter, the empirical results are in terms of the one-year lagged values of ($\delta - 0.85$).

[38]The effect of the natural rate of labor force growth was not significantly different from zero in the various regressions. This reflects the small variation in the data for this variable. It was included here in order to maintain consistency with the CCS equation, but henceforth this term will be neglected.

[39]Other exogenous variables, such as education and age distribution, were not treated in this analysis because data were not available. Judging from the CCS analysis, however, it is unlikely that introducing these variables would have changed the results substantially.

## Table 6—Estimates of the migration equation, postwar Japan

| Regression Number | Intercept | Income differential ($\delta - 0.85$), Lagged One Year | Labor Force Ratio ($r$) | Natural Labor Force Growth Rate ($l+n$) | First-Order Serial Correlation[a] | $R^2$ | Durbin-Watson Statistic |
|---|---|---|---|---|---|---|---|
| 1 | −3.751 | 0.591 | 0.165 | 4.94 | 0.438 | 0.741 | 1.97 |
| | | (1.70) | (1.32) | (0.82) | | | |
| 2 | −3.720 | 0.843 | | | 0.509 | 0.705 | 1.95 |
| | | (3.400) | | | | | |
| 3 | −3.311 | | 2.71 | | 0.522 | 0.700 | 1.80 |
| | | | (3.07) | | | | |
| 4 | −3.553 | 0.232[b] | 0.252 | 4.818 | 0.478 | 0.725 | 1.90 |
| | | | (2.7) | (.8) | | | |
| 5 | −3.714 | 0.232[b] | 0.372[b] | 8.73 | 0.520 | 0.717 | 2.0 |
| | | | | (1.6) | | | |
| 6[c] | −3.755 | 0.232[b] | 0.372[b] | 10.883[b] | 0.518 | 0.712 | 2.0 |

[a]Estimated from the data and used for second-stage least squares correction.
[b]Value imposed from the CCS equation.
[c]The $\delta$ variable used for Table 5 was not lagged, so there is a slight variation between this line and the last line of Table 5.

rate of growth of the gross national expenditure in constant prices ($g_y$). A third-degree polynomial was fitted to the *annual* data for the period 1910 to 1940 with the following result:

$$\ln(m+.025) = -3.449 + 12.967\, g_y - 430.969\, g_y^2 + 3689.g_y^3, \qquad (3.1)$$

$$(3.11) \qquad (-3.90) \qquad (2.75)$$

$R^2 = 0.610$
First-order serial correlation = −0.377
Durbin-Watson Statistic = 2.190

where $\bar{g}_y = g_y + 1$, and numbers in parentheses are $t$-ratios.

The next step was to combine the rate of growth ($g_y$) with the CCS equation in a form that preserves the nature of the equation.[40] For instance, the $\delta$ coefficient and intercept were allowed to differ for years where $\delta$ increased or decreased. There was an improvement in the fit, but it was not sufficient to sustain empirically all the coefficients.

[40]Ohkawa and Rosovsky, *Japanese Economic Growth*, attribute much of the variation in the sectoral labor force to the swings of the economy.

It was decided to search for a formulation more efficient in terms of the number of parameters in order to overcome the difficulty of sustaining all the variables in the regression. A natural way to reduce the number of parameters was to take a product of the two variables, $(\delta - 0.85)$ and $r$. This led to the equation:

$$\ell n\, m = \beta_0 + \beta_1 I_1 + u, \tag{3.2}$$

*where*

$I_1 = \ell n(\delta - 0.85)\, \ell n r.$

According to (3.2), the partial derivative of one variable depends on the level of the other variable. Specifically, the elasticity of migration with respect to the income differential depends on the labor force ratio. The effect of the income differential increases with $r$, indicating that a given percentage change of $(\delta - 0.85)$ has a larger effect the larger $r$ is or the smaller is the share of agriculture in the total labor force. It should be remembered that $m$ is the proportion of migrants in the agricultural labor force; the response of *absolute* migration to changes in $r$ will be somewhat weaker than that of *relative* migration.

The elasticity of $m$ with respect to the income differential may also depend on the overall performance of the economy, and this may be treated similarly by introducing into (3.2) the term $I_2 = \ell n(\delta - 0.85)\, \ell n\, (g_y + 1)$. The resulting equation was also fitted to the annual data.[41]

$$\ell n(m + c_0) = \beta_0 + \beta_1 I_1 + \beta_2 I_2 + u. \tag{3.3}$$

$U$ is allowed to have an autoregressive structure, but otherwise it is assumed to possess the standard properties.

The coefficients estimated by (3.2) and (3.3) appear in Table 7. The table is divided into three panels: postwar, prewar, and both periods combined. For each period, results were obtained for the five-year moving averages and for the annual data, and for selected values of $c_0$. Also for five of the regressions, no correction was made for the first-order serial correlation.

Comparing the postwar period results with those using cross-section data, the coefficients of $I_2$ are not significantly different from zero. Other attempts to bring in the level of economic activity did not improve the results in an important way. This was true both for moving-average and for annual data. It is, however, important to note that the coefficient of $I_1$ in regression 5 (annual) is close to that of 4 (the corresponding moving-average equation).

It appears that for the postwar period, regression 2 of Table 7 summarizes that data well. The partial derivatives with respect to $\delta$ and $r$ obtained from this equation are shown in Figure 2. The coefficient (elasticity) with respect to $r$ varies between 0.13 in 1951 to about 0.31 in 1966: recall that the constant elasticity in the CCS equation was 0.392. Similarly, the elasticity with respect to $(\delta - 0.85)$ varies between zero in 1951 to 0.5 in 1972, as compared with the constant elasticity of 0.232 from the CCS equation. These represent similar orders of magnitude.

---

[41] A constant, $c_0$, is added because in some years migration was negative.

## Table 7—Alternative forms for the migration equation

| Regression Number and Period | Type of Data[a] | $c_0$ | Intercept | $l_1$ | | $l_2$ | | $\ln(g_t + 1)$ | | Prewar Dummy[b] | First-Order Serial Correlation[c] | $R^2$ | Durbin-Watson Statistic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Postwar[d] | | | | | | | | | | | | | |
| 1) | FMA | 0 | −3.311 | 0.360 | (5.9) | | | | | | | 0.632 | 1.1 |
| 2) | FMA | 0 | −3.312 | 0.349 | (4.0) | | | | | | 0.429 | 0.727 | 1.8 |
| 3) | FMA | 0 | −3.393 | 0.425 | (5.1) | 0.924 | (0.8) | | | | 0.341 | 0.858 | 1.9 |
| 4) | FMA | 0.025 | −2.838 | 0.281 | (5.0) | 0.464 | (0.6) | | | | 0.361 | 0.853 | 1.9 |
| 5) | Annual | 0.025 | −2.889 | 0.259 | (1.5) | 0.889 | (1.0) | | | | | 0.183 | 2.0 |
| Prewar | | | | | | | | | | | | | |
| 6) | FMA | 0 | −5.107 | −0.230 | (−0.3) | 10.747 | (1.8) | | | | 0.652 | 0.573 | 1.9 |
| 7) | FMA | 0.025 | −3.452 | −0.061 | (−0.3) | 2.714 | (2.0) | | | | 0.714 | 0.667 | 2.0 |
| 8) | Annual | 0.025 | −3.711 | −0.362 | (−1.0) | 6.811 | (3.5) | | | | −0.437 | 0.336 | 2.2 |
| Both periods[e] | | | | | | | | | | | | | |
| 9) | FMA | 0.025 | −3.334 | 0.484 | (4.6) | 3.888 | (2.6) | | | | | 0.654 | 0.2 |
| 10) | FMA | 0.025 | −0.328 | 0.424 | (1.9) | 1.968 | (2.3) | | | | 0.900 | 0.944 | 2.0 |
| 11) | FMA | 0.025 | −0.583 | 0.310 | (2.2) | 1.976 | (2.3) | | | −.25 | 0.810 | 0.947 | 1.9 |
| 12) | FMA | 0.060 | −0.262 | 0.278 | (2.2) | 1.071 | (2.3) | | | | 0.900 | 0.951 | 1.9 |
| 13) | Annual | 0.025 | −3.407 | 0.576 | (3.0) | 3.239 | (2.1) | | | | | 0.299 | 2.3 |
| 14) | Annual | 0.025 | −4.066 | 0.333 | (2.2) | 4.066 | (2.9) | | | −.25 | −0.250 | 0.411 | 2.1 |
| 15) | Annual | 0.025 | −3.368 | 0.585 | (3.0) | | | 2.147 | (2.0) | | | 0.292 | 2.3 |

[a]FMA = five-year moving average.
[b]Imposed value.
[c]FOC was obtained from residuals of the OLS regression and was then used to obtain the second stage estimates reported in the table.
[d]Regressions 1 and 2 are for 1951-72; all other postwar regressions are for 1951-70.
[e]The war years are omitted, so the two periods included are 1911-40 and 1951-70.

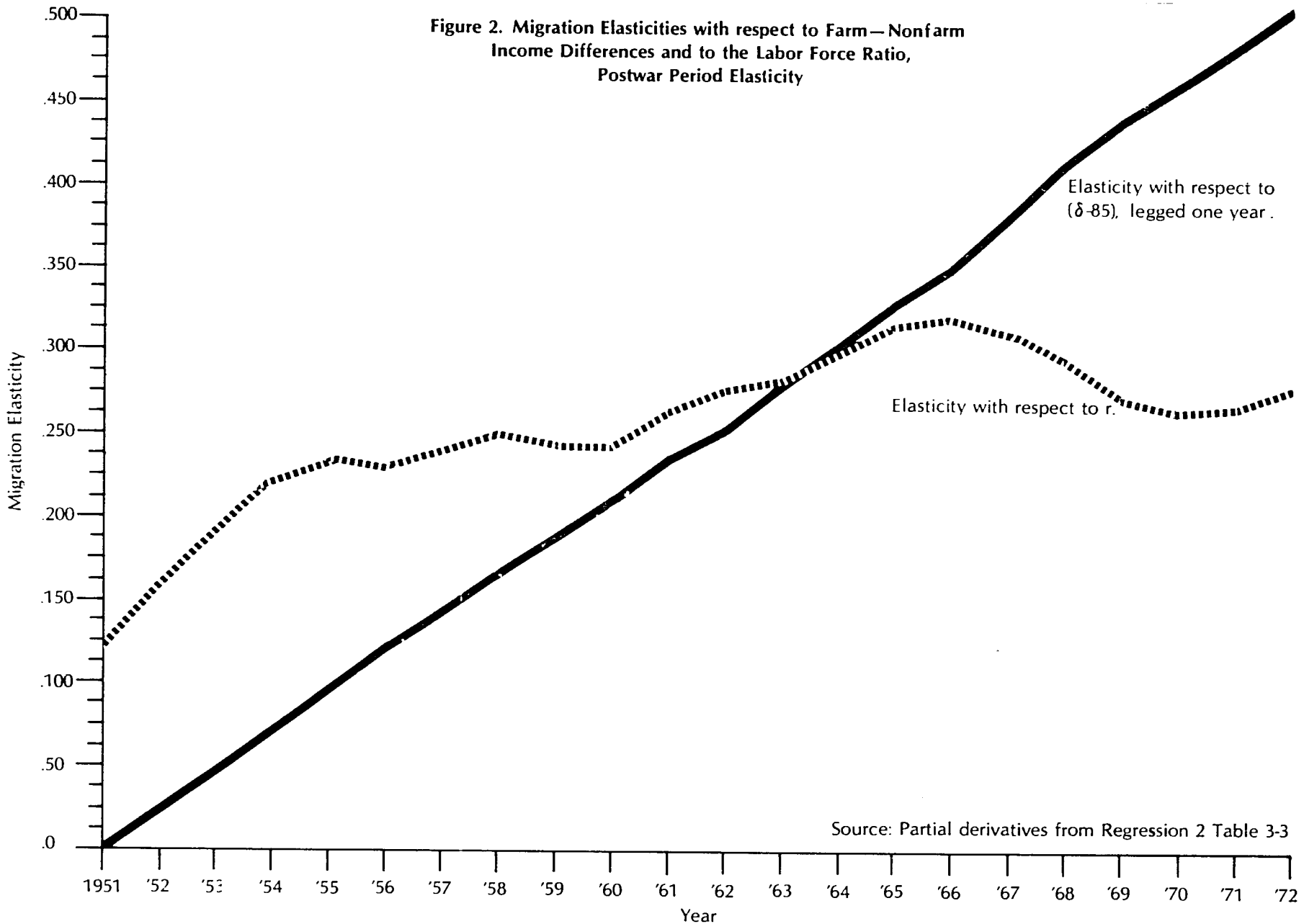


Figure 2. Migration Elasticities with respect to Farm—Nonfarm Income Differences and to the Labor Force Ratio, Postwar Period Elasticity
Elasticity with respect to (δ-85), legged one year.
Elasticity with respect to r.
Source: Partial derivatives from Regression 2 Table 3-3
Migration Elasticity
.500
.450
.400
.350
.300
.250
.200
.150
.100
.50
.0
1951
'52
'53
'54
'55
'56
'57
'58
'59
'60
'61
'62
'63
'64
'65
'66
'67
'68
'69
'70
'71
'72
Year

Turning to the prewar year, $I_1$ is not significantly different from zero. On the other hand, $I_2$ passes the null test with both types of data, but only marginally so for the moving averages. Regression 8 is the only regression that catches the effect of the income differential in the prewar years. The elasticity of relative migration with respect to ($\delta$ – 0.85) derived from this regression is $(m + .025)/m\ 6.811\ \ell n(g_y + 1)$. The extreme moving-average values of $g_y$ in the prewar period and the corresponding values of $m$ were:

| Year | $g_y$ | $m$ | elasticity |
|---|---|---|---|
| 1919 | 0.07417 | 0.0172 | 1.196 |
| 1924 | 0.00126 | 0.0099 | 0.030 |

It appears that the range of the prewar elasticitv with respect to the income differential covers larger values than for the postwar period.

The equations for the prewar period in Table 7 are preferable to the cubic equation (3.1), which includes only the effects of economic growth. Because of the large variance of the error term, statistical comparisons of the two were not performed; but evidence suggests a response to the income differential in the prewar period. This evidence is amplified when data for the prewar and postwar periods are pooled so as to add the between-periods variations.

Regressions 9 and 10 in Table 7 give the results with and without correction for the first-order correlation. There is a close correlation between the prewar effect on the intercept and $I_1$, which results from the monotonicity of $r$ with time. To allow for this effect, a dummy for the prewar effect was added in regression 11, and its coefficient was restricted to a level that still leaves the other coefficients significant; the significance of $I_1$ is reduced, however. Iterations on $c_0$ indicated that the fit could be improved somewhat by setting $c_0 = 0.06$ (regression 12).

The moving-average regressions now are subject to high first-order correlation. To see if this is avoided by using annual data, regressions 13 and 14 are compared with regressions 10 and 11, respectively. The coefficients of $I_1$ conform quite well, but there are large differences in the coefficients of $I_2$ and in the intercepts. The poor fit of the annual data compared with the moving-average data indicates that the equation predicts the rate of migration better than the exact timing. Thus, there is a great deal of annual variation fluctuating around the systematic component, which itself varies with the explanatory variables.

## Summary and Conclusions

A migration equation was formulated and estimated using Japanese data for the period 1910 to 1972, excluding the war years 1941-50. Migration was explained in terms of income differences between the agricultural and nonagricultural sectors. The relative sizes of the two sectors and the labor force rate of growth were taken into account. The same equation was estimated previously from country cross-section data for the OECD countries for the postwar period. Here, a measure of the economic

rate of growth was introduced into the equation to represent expectations with respect to obtaining employment in the nonagricultural sector.

In the initial empirical analysis of the Japanese data the country cross-section data was applied to the Japanese postwar data, and the fit was found to be "reasonable." In the postwar period, Japan had a migration rate 16 percent higher than that which could be accounted for by the explanatory variables. Coefficients for the same equation are then estimated using the postwar Japanese data; there was a little improvement in fit. Fitting the same equation to the prewar data did not yield significant results. The rate of growth of the labor force did not contribute much to the explanation and it was omitted in further analysis. On the basis of this analysis, it is concluded that postwar migration in Japan can be attributed to the farm-nonfarm income differential and the composition of the labor force.

The formulation was then changed so as to bring in the effect of economic growth of migration; this was done to capture any effect that changes in the level of economic activity might have on the subjective probabilities of obtaining a job within a given period. The results indicate that this variable was important in the prewar, but not in the postwar, period. The prewar period was one in which there were substantial fluctuations in overall activity levels and therefore the prospects of finding employment, and expectations with respect to such prospects, also fluctuated. There was a statistically important spread in this variable. On the other hand, the postwar period has been one of continuous growth, with only moderate variations in the rate of growth. Consequently, employment expectations have not changed much; they have been favorable throughout. As a result the important determinants of migration have been income differentials and the labor force composition.

It should be noted that, once the expectation variable was introduced along with the other two variables, the income differential, which taken alone had little explanatory power in the prewar period, became important in explaining the relatively low rate of migration during this period. The three-variable formulation permits pooling data for the two periods so as to make use of the variations between the periods.

In conclusion, all the economic variables have the expected qualitative effects, and there is no reason to rule out the importance of income differentials in explaining migration.

# 4

## THE FLOW OF SAVINGS OUT OF AGRICULTURE— THE CASE OF JAPAN

The process of allocating production factors among sectors over time is not restricted to labor. In this chapter, we consider the intersectoral flow of savings. There is a basic difference between the flow of labor and that of capital. The total labor force of a particular sector, and not just the addition to the labor force, is movable within a given period. This is not the situation with respect to capital; a good portion of existing capital is sector specific. Thus, it is better to assume that the allocation decision is made primarily with respect to new investment and that the most that can be invested during any given year is the gross savings of the economy for that year.

There is also a practical difference between labor and capital: the data necessary for analyzing the flow of savings are less available than those for labor force changes. Even indirect computations of the flow variable and expected rates of returns require data that do not always exist. Often it may be necessary to exploit whatever data are available, even if some of the findings offer only a first working hypothesis. This was the case in estimating the flow of savings equation for Japan.

Japanese agriculture is thought to have played an important role in financing investment for industrialization. According to Ohkawa and Rosovsky, "agriculture was a source of savings in the economy and these savings were translated into investment, i.e., capital formation."[42] The study of the Japanese experience is handicapped by lack of data, but with a relatively weak assumption it is possible to compute investment flows by using standard national accounting data. Such data are used in various other econometric analyses, and there is no reason why they should not also be used in this one. Nevertheless, Ohkawa and Rosovsky have cautioned that data on investment flows are inadequate, so analysis based on the Japanese national accounts must be taken as tentative and should be verified with additional information.

The plan of this chapter is as follows: the savings flow equation is formulated in the next section, followed by a discussion of the variables; the empirical results are discussed in some detail in the third section and are summarized in the final section. Methods of estimating the sectoral saving rates, sources of data, and summary statistics can be found in Appendix C.

### The Model of Intersectoral Savings Flows

The agricultural and nonagricultural sectors each generate savings that can be

[42]K. Ohkawa and H. Rosovsky, "The Role of Agriculture in Modern Japanese Economic Development," *Economic Development and Cultural Change* 9 (1960): 60; cf. K. Ohkawa, "Agricultural Policy: The Role of Agriculture in Early Economic Development," in *Economic Development with Special Reference to East Asia*, K. Berrill, ed. New York: St. Martin's Press, 1964, p. 323.

invested in either sector. If $F$ denotes the net flow of savings from sector 1 to sector 2, then total savings (or investment) in each sector may be defined as

$$S_1 = I_1 + F, \qquad S_2 = I_2 - F. \tag{4.1}$$

A basic assumption of our analysis is that the flow of savings is determined by expected returns on investment in the two sectors, that is,

$$F \sim \phi(\delta_r^e), \ \phi' > 0 \tag{4.2}$$

where

$\delta_r$ $= r_1/r_2$,

$r$ = return on capital in the designated sector, and

e = expectations.

It is also assumed that for any value of $\delta_r^e$, the size of the flow depends on the magnitude of the savings in the two sectors; the larger the sector's savings, the larger is the flow. Also, other things being equal, it is easier to invest a certain amount in a large capital market than in a small one. If the size of the market is measured by $S$, and we assume that $F$ is monotonically increasing in $S_1$ and $S_2$, then

$$f = \frac{F}{S_1} = \phi(\delta_r^e)\left(\frac{S_2}{S_1}\right)^{\beta}, \quad 0 < \beta < 1 \tag{4.3}$$

This relation should maintain the constant returns to scale hypothesis, so that for any given $\delta_r^e$, doubling $S_1$ and $S_2$ should double $F$.

To formulate (4.3) more explicitly for empirical study, we assume it to be of the Cobb-Douglas form. To allow for a zero flow, we use the variable $(\delta_r^e - c_1)$ instead of $\delta_r^e$, where $c_1$ is some constant. Also, to allow for a negative $F$—that is, a flow of savings from sector 2 to sector 1—we add a constant $c_0$ to the left-hand side. The equation can then be written as:

$$\ln(f + c_0) = \beta_0 + \beta_1 \ln(\delta_r^e - c_1) + \beta_2 \ln R + u, \tag{4.4}$$

where $R = S_2/S_1$, and $u$ is a disturbance term, which we assume to possess the standard properties.

## Variables and Data

Data for variables in (4.4) are not readily available, particularly for the flow variable

*F*. *F* was obtained by using (4.1) to write:

$$f = 1 - \frac{I_1/S}{S_1/S}, \tag{4.5}$$

where $S = S_1 + S_2 = I$.[43]

Elaborating on (4.5), the savings in any sector may be defined as a product of its saving rate and its output. For sector 1, for example, $S_1 = s_1P_1Y_1$, where $s_1$ is the saving rate, $Y_1$ is agricultural output and $P_1$ is its price. The flow of savings from sector 1 to sector 2, then, can be written as:

$$f = 1 - \rho_I\left(1 + \frac{1-\pi}{\pi\lambda}\right) \tag{4.6}$$

where

$\rho_I = I_1/I$,

$\pi = P_1Y_1/P_1Y_1 + P_2Y_2$, and

$\lambda = s_1/s_2$.

In order to compute $f$ by using (4.6), the share of sector 1 in output and in gross investment must be known; these data are readily available. The ratio of savings rates in the two sectors must also be known, but we do not have such data.[44] Therefore, we computed and used $f$ under various assumptions with respect to the savings ratio; the different $f$ series are highly correlated.

There are also no measurements of $\delta_r^e$, nor are there direct measurements of the ratio of returns in the two sectors. The rates of returns were obtained indirectly. Using data on capital shares and on average productivities, the rate of return on capital ($r$) in any one sector is equal to $(PY/K)\beta$ in that sector, where $\beta$ represents the sector's capital shares and $K$ its capital stock.[45] There are limitations on these data, too, however. Available figures on factor shares in agriculture change every five years, rather than annually, and they appear to be based on assumptions with respect to the interest rate—which is what we were seeking in the first place.

Because of these deficiencies, we decided to approximate marginal returns by using average returns. This provides two possible measures:

$$\delta_r = \frac{P_2Y_2}{K_2}\beta_2 \Big/ \frac{P_1Y_1}{K_1}\beta_1, \quad \text{and} \tag{4.7}$$

$$\delta_{ar} = \frac{P_2Y_2}{K_2} \Big/ \frac{P_1Y_1}{K_1} \tag{4.8}$$

[43]Following Ohkawa in "Agricultural Policy," p. 333, we neglect capital import or export.

[44]Some attempts to estimate the sectoral savings rates are discussed in Appendix C. However, the computation of $f$ does not depend on the actual values of $s$, nor on the assumption that these values are constant; it is only necessary to assume that their ratio is constant.

[45]Sources of these data are discussed in Appendix C.

$\delta_{ar}$ ignores the ratio of capital shares in the two sectors. If this ratio is fairly stable, $\delta_{ar}$ may yield an accurate approximation, up to a scalar, of the ratio of returns to capital.[46]

The data for marginal and average returns are plotted in Figure 3. Both measures show a considerable difference in returns between the sectors. The reasons for this difference and the behavior of the rates over time will not be explored here, but the considerably higher rates of return in the nonagricultural sector may well explain the flow of savings out of agriculture during most of the period examined.

To obtain some indication of how expectations affect savings flows, we formed the product, $INT = \ell n(\delta - c_1)\,\ell n(1.1 + g_y)$, where $g_y$ is the rate of growth of the economy. The idea is that expectations improve with high rates of growth and increase the flow of investment for any given value of $\delta$.[47]

Under this alternative, (4.4) takes the form:

$$\ell n(f + c_0) = \beta_0 + \beta_1\,\ell n(\delta - c_1)\,\ell n(1.1 + g_y) + \beta_2 \ell n R + u. \qquad (4.9)$$

In a final variation on equation (4.4), instead of using $R = S_2/S_1$ we use the ratio ($\pi$) of the sectoral outputs to total output; that is, $R = (1 - \pi)/\pi$. When the ratio of the saving rates in the two sectors remains fairly constant, $R$ provides a good approximation up to a scalar.

Our manipulation of (4.4) yielded a rich variety of combinations with which to estimate the flow equation. These combinations reflect (1) iterations to find the best fitting $c_0$ and $c_1$, (2) the search for the effect of changing the ratio $s_1/s_2$, (3) the choice between $\delta_r$ and $\delta_{ar}$ as measures of the differential returns, and (4) the attempts to eliminate some of the possible errors in the $\delta$ variable by using instrumental variables estimates. In view of the exploratory nature of this work and the lack of similar studies, estimates were obtained under alternative assumptions so as to gain some notion of the empirical meanings of such assumptions.

## Empirical Results

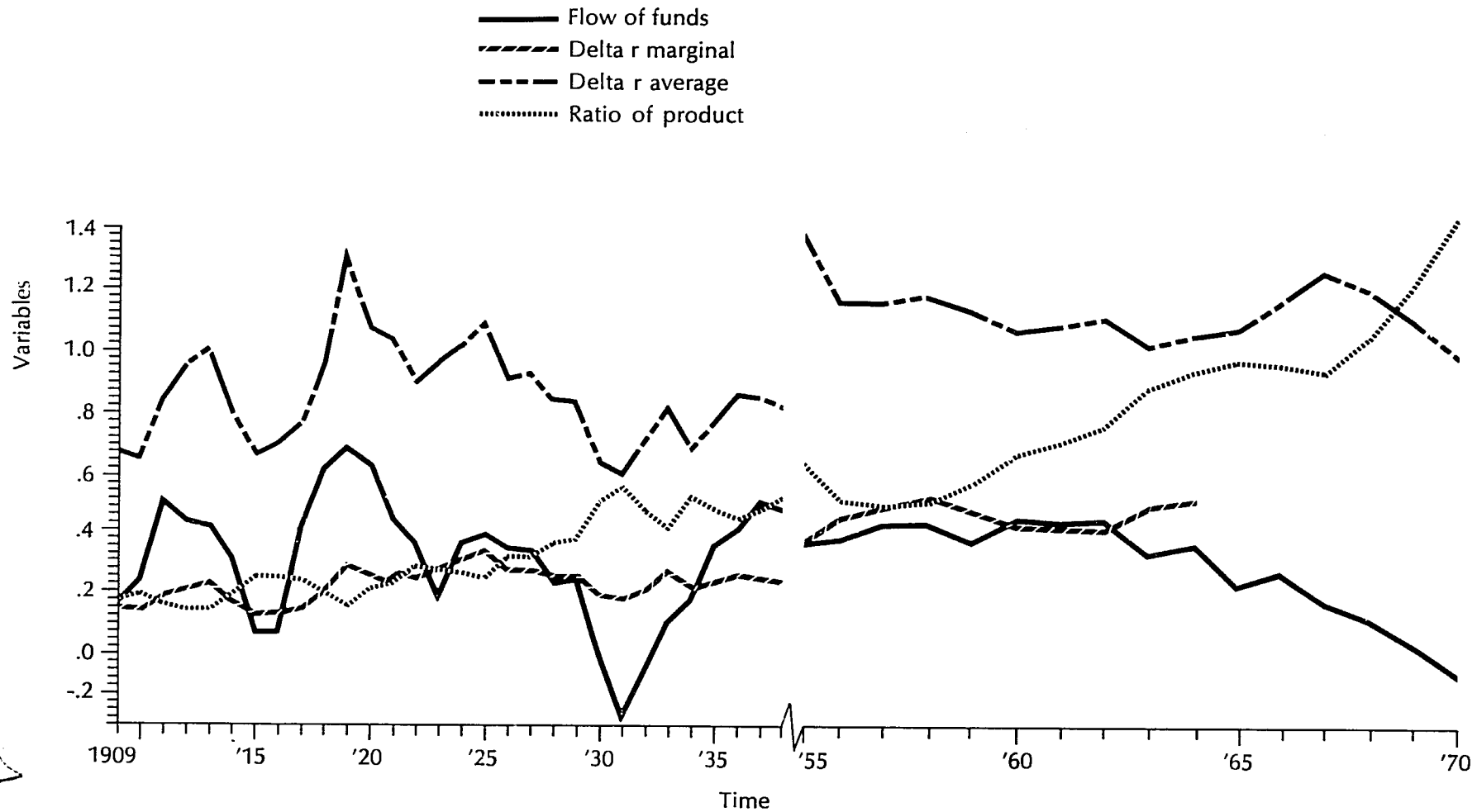
Figure 3 shows that the prewar savings flow calculated for $\lambda = 1$ was subject to fluctuations. Its highest value, 69.4 percent, was reached following World War I, when in 1919 the economy reached a local peak in activity. The lowest value,—18 percent—representing a flow of savings from the nonagricultural to the agricultural sector—occurred in the midst of the depression. The post-World War II data are characterized by a downward trend in $F$ and much narrower fluctuations. The savings flow fluctuated around 40 percent in the late 1950s and early 1960s and then declined almost continuously until it finally reached a negative value in 1970.

The analysis was first conducted separately for two periods, 1909 to 1938 and 1955 to 1970; later the data were pooled. The results are summarized in Tables 8 through 10.

[46]Note that when dealing with logarithmic transformations, the scalar becomes additive, and in linear forms it is absorbed in the intercepts.

[47]Because in some years $g_y$ is negative, we added a constant to $g_y$ so that the variable is always positive. Furthermore, we wanted the $\ell n$ of the variable to preserve its sign, so we selected this constant to be 1.1 rather than 1.

Figure 3. **Flow of Funds and Related Variables 1909-1938, 1955-1970**



## Table 8—Estimates of the flow equation for the prewar period, 1909-38

| Regression Number[a] | Intercept | | $\lambda$[b] | $c_0$ | $c_1$ | INT[c] | | $\ell n$ R | | Serial Correlation: First-Order | Serial Correlation: Second-Order | $R^2$ | Durbin-Watson Statistic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.(i) | 0.320 | (0.7) | 1.0 | 0.25 | 0 | −1.73 | (2.3) | −0.54 | (1.6) | 0.613 | | 0.531 | 1.7 |
| 2. | 0.673 | (1.1) | 1.0 | 0.25 | 0 | −8.80 | (2.6) | −1.34 | (2.7) | 0.822 | | 0.538 | 1.8 |
| 3. | 0.042 | (0.1) | 1.0 | 0.25 | 0.5 | −2.27 | (2.8) | −0.88 | (2.3) | 0.723 | | 0.566 | 1.6 |
| 4. (ii) | 0.020 | (0.03) | 1.0 | 0.25 | 0 | 3.39 | (2.6) | −1.2 | (2.4) | 0.822 | | 0.538 | 1.8 |
| 5. (ii) | 0.228 | (0.05) | 1.0 | 0.25 | 0.5 | 2.41 | (2.8) | −0.74 | (1.9) | 0.723 | | 0.566 | 1.6 |
| 6. | 0.754 | (1.3) | 0.8 | 0.05 | 0 | 8.80 | (2.4) | −1.24 | (2.5) | 0.760 | | 0.519 | 1.8 |
| 7. | 0.524 | (0.9) | 1.2 | 0.01 | 0 | 7.85 | (2.6) | −1.28 | (2.8) | 0.866 | | 0.561 | 1.7 |
| 8. | −0.114 | (−0.3) | 1.2 | 0.01 | 0.5 | −1.95 | (2.8) | −0.80 | (2.3) | 0.758 | | 0.585 | 1.5 |
| 9. | 0.129 | (0.3) | 1.5 | 0 | 0 | −5.02 | (2.3) | −0.88 | (2.6) | 0.874 | | 0.581 | 1.5 |
| 10. | 0.154 | (−0.6) | 2.0 | 0 | 0 | −2.19 | (1.6) | −0.40 | (2.0) | 0.843 | | 0.569 | 1.4 |
| 11.[e] | 0.588 | (6.0) | V | 0 | 0 | −2.80 | (2.1) | −1.9 | (1.4) | 1.10 | −0.49 | 0.669 | 2.2 |
| 12.[e] | 0.680 | (7.6) | V | 0 | 0.5 | −1.05 | (4.0) | −0.18 | (1.6) | 1.18 | −0.59 | 0.746 | 2.1 |
| 13. (i)[e] | 0.703 | (7.4) | V | 0 | 0 | 0.762 | (3.2) | −0.12 | (1.0) | 1.07 | −0.49 | 0.724 | 2.2 |

Note: The independent variables are lagged one year. Figures in parentheses are the absolute values of the t-ratios.

[a](i)—in this equation $\delta_r$ is used for the differential returns, otherwise $\delta$ is used. (ii)—The equation was estimated by the instrumental variables method, and $\delta_{ar}$, or INT derived from $\delta_{ar}$, serves as the instrumental variable.

[b]V—variable $\lambda$ as obtained from Appendix C.

[c]INT = $\ell n(\delta - c_1)\ell n(1.1 + g_y)$, where $\delta_{ar}$ is used for $\delta$ unless otherwise indicated (see note [a] above) and $g_y$ is the rate of growth of per capita gross national expenditures.

[d]$R^2$ obtained by 1 − Sum of squares residuals/sum of squares total.

[e]For variable $\lambda$, instead of $\ell n\ R$, the variable used is $\ell n\ (R/\lambda)$.

## Table 9—Postwar estimates of the savings flow equations, 1955-64 and 1954-70

| Regression Number and Period | Intercept | $\lambda$ | $c_0$ | $c_1$ | $\ln(\delta - c_1)$ | INT | $\ln R$ | $R^2$ | Durbin-Watson Statistic |
|---|---|---|---|---|---|---|---|---|---|
| 1955-64 | | | | | | | | | |
| 16[a] | −0.250 (2.5) | 1 | 0.25 | 0 | | −1.85 (3.4) | −0.21 (2.8) | 0.633 | 1.9 |
| 17 | −0.025 (0.2) | 1 | 0.25 | 0.5 | | −2.70 (3.4) | −0.33 (3.2) | 0.626 | 1.9 |
| 18 | 0.119 (0.6) | 1 | 0.25 | 0.5 | −0.48 (1.6) | | −0.28 (1.6) | 0.279 | 1.9 |
| 1954-70 | | | | | | | | | |
| 19[b] | 0.659 (0.8) | 1 | 0.25 | 0.5 | −0.64 (1.7) | | −0.91 (2.0) | 0.859 | 2.0 |

Note: Also see Table 8.
[a]Based on $\delta_t$ rather than $\delta_{ar}$.
[b]Corrected for second-order autoregression.

## Table 10—Estimates of the savings flow equation, data pooled

| Regression Number and Period | Intercept | $\lambda$ | $c_0$ | $c_1$ | INT | $\ln R$ | Prewar Effect | Auto-regression | $R^2$ | Durbin-Watson Statistic |
|---|---|---|---|---|---|---|---|---|---|---|
| 1910-38 and 1956-64 | | | | | | | | | | |
| 20[b] | 0.235 (0.9) | 1 | 0.25 | 0 | −1.71 (2.6) | −0.65 (2.1) | −0.755 (1.9) | 0.625 | 0.551 | 1.8 |
| 21 | 0.488 (1.9) | 1 | 0.25 | 0.5 | −2.25 (3.2) | −0.98 (3.0) | −1.000 (2.7) | 0.625 | 0.58 | 1.5 |
| 22[c] | 0.297 (1.2) | 1 | 0.25 | 0 | −2.36 (3.1) | −0.78 (2.5) | −0.876 (2.2) | 0.625 | 0.580 | 1.5 |
| 1910-38 and 1955-70 | | | | | | | | | | |
| 23 | 0.482 (2.3) | 1 | 0.25 | 0.5 | −2.29 (3.4) | −1.09 (3.9) | −0.992 (2.7) | 0.650 | 0.619 | 1.6 |

Note: Also see Table 8.

[a]One year is lost at the beginning of the second period because of the method used for eliminating the first-order serial correlation.

[b]Based on $\delta_r$ rather than $\delta_{ar}$.

[c]Instrumental variable estimates. Where INT was computed with ($\delta_{ar}$ − 0.5), the instrument was ($INT_t$ − 0.650 $INT_{t-1}$).

Unless otherwise specified, the $\delta_{ar}$ series was used for $\delta$. The variables are lagged one year in order to avoid spurious correlation because of the appearance of $\pi$ on both sides of the equation. Lagging may also be appropriate because of some lag in the response of investment to returns on capital.

In general, the fit improves somewhat with lower values of $c_0$. Thus, in the search for estimates of the other parameters, we used low values of $c_0$ but not so low that $F + c_0$ would be zero or negative. Different values of $\lambda$ result in different $F$ series, so $c_0$ had to be changed accordingly. The fit also improves as values of $c_1$ increase. The limit to the increase in the value of $c_1$ is set by the smallest value of $\delta$, because $\delta - c_1$ should always be positive. For that reason, $c_1$ was only applied to $\delta_{ar}$ series; the values of $\delta_r$ are so low that introducing the $c_1$ coefficient would produce a negative value.

In regression 1 in Table 8 the INT variable was computed with $\delta_r$, whereas in regression 2 the $\delta_{ar}$ series was used. There is a little difference in the fit, but in all cases the difference was only moderate. The main difference between the first two regressions is in the size of the coefficients, which occurs because the variables are different. Changing the value of $c_1$ in regression 2 from 0 to 0.5 leads to regression 3; that change reduced the standard error of the INT coefficient somewhat.

The $\delta$ series and the $\delta_{ar}$ series are not identical, and they both can be subject to independent errors. For this reason, it is possible to use one series as an instrumental variable in estimating an equation with the other series. The results in line 4 are instrumental variable estimates of the regression estimated in line 1 in which the instrument is $\ln \delta_{ar} \ln(1.1 + g_y)$. Similarly, the results in line 5 are instrumental variable estimates of the same regression in which the instrument is $\ln(\delta_{ar} - 0.5) \ln(1.1 + g_y)$.

The remaining prewar regressions use different values of $\lambda$ (the ratio of the saving rates). The different $f$ series, which were obtained by changing the ratio of the saving rates, are highly correlated, but their actual values differ and so do the resulting regression coefficients. Differences among the various regressions in $t$-ratios and in fit are not large enough to allow a clear-cut empirical choice among the values of $\lambda$. Independent information would be necessary to select the correct $\lambda$, but not having such information, we have tried to extract it from the data with somewhat inconclusive results.[48] The results suggest that in the prewar period $\lambda$ varied within the range of approximately 1.5 through 2, with an average value of 1.78.

An $f$ series was also constructed under the assumption that $\lambda$ varies. Regressions 11 through 13 are derived from this series. Regression 11 incorporates the same assumptions as regressions 9 and 10, except for $\lambda$. The value of $\lambda$ varies between 1.5 and 2, and it is seen that the coefficient of INT falls between the values it had when $\lambda$ was treated as a constant set at 1.5 or at 2. The value of the INT coefficient increases when correction is made for second order autoregression.

Regression 12 is like 11 except that $c_1$ is set at 0.5 rather than 0, which has the effect of reducing the value of the coefficient of INT. Regression 13 is obtained by using $\delta_r$ rather than $\delta_{ar}$. The result is to decrease the coefficient of INT and bring it closer to that obtained for $c_1 = 0.5$.

---

[48]This analysis is summarized in Appendix C.

The pattern established in these estimates is that the results obtained for the prewar data in which the $F$ series was derived from a varying $\lambda$ are similar to those from a constant $\lambda$ if this constant ratio is set at values within the range of $\lambda$'s variation. The evidence on $\lambda$ is not conclusive, so not much is lost by continuing the analysis under the assumption of equal saving rates.

The results for the postwar period appear in Table 9. The analysis is conducted for a short period, 1955-64, and a longer period 1954-70. The shorter period was chosen because the $\delta_r$ series is only available for this period, but it also has another significance—Table 9 shows that the savings flow variable started a steep downward trend in 1964. That strong trend has been reflected in a strong second-order autoregressive scheme in the regressions calculated for the longer period. For that reason, the results for the shorter period may be more reliable, despite the fact that the number of observations is smaller.

Looking at the results for the shorter period, regressions 16 and 17 are, respectively, the postwar versions of regressions 1 and 3 of Table 8. In the $\delta_r$ series (16), the coefficients of the INT variable are quite close to the prewar values, and there is a somewhat greater difference for the $\delta_{ar}$ series (17). This difference is not substantive when the standard errors are considered, however. The results for the shorter period are not subject at all to autoregression.

For the series based on $\delta_{ar}$, it is possible to obtain regression 19 for the longer period. Probably because of the strong autoregressive scheme, the coefficient of the INT variable is not significant. Better results are obtained by using $\ell n(\delta_{ar} - 0.5)$ as a variable, rather than INT. Regression 19 is comparable to regression 8 in Table 8, which is the same regression for the shorter period. The coefficients of $\ell n(\delta_{ar} - 0.5)$ and INT are similar for the two regressions. For the shorter period, the fit using $\ell n(\delta_{ar} - 0.5)$ is much worse than that for INT. Thus, INT appears to be a superior variable for that subperiod. The good fit in regression 19 is largely because of the second-order correction for autoregression.

One way to avoid some of the difficulties is to pool the data for the two subperiods. These results are reported in Table 10. Regression 20 is the pooled-data version of regressions 1 and 16. In all cases, the coefficients of INT are very close. There are differences in the coefficients of $\ell n\, R$, and the prewar intercept is negative. Similarly, regression 21 is the pooled-data version of regressions 3 and 17. The coefficient of INT in 21 is very close to that of the prewar period. Using INT with $(\delta_{ar} - 0.5)$ corrected for serial correlation, as an instrumental variable for $\delta_r$, has little effect on the coefficient of INT, as can be seen from regression 22. Extending the period to 1970 in regression 23 also changes the coefficient of INT very little.

Our ultimate interest in these estimates was to capture the partial effect of differential returns on capital ($\delta$) on the savings flow. Apparently this effect differs with the $f$ series, and thus it depends on $\lambda$. It also depends on whether the $\lambda$ or the $\delta_{ar}$ is used and which value of $c_1$ is used. A comparison of the calculated coefficients for several of the cases considered appears in Table 11. The elasticity of the savings flow with respect to differential returns ($\delta$) may be written:

$$\frac{\partial f}{\partial \delta} = \frac{\partial \ell n(f + c_0)}{\partial \ell n(\delta - c_1)} \quad \frac{df}{d\ell n(f + c_0)} \quad \frac{d\ell(\delta - c_1)}{d\delta}$$

## Table 11—The Response of savings flow to differential returns on capital

| Regression Number | $\lambda$ | $c_0$ | $c_1$ | $-\partial \ell n (f + c_0)/\partial \ell n (\delta - c_1)$ Average | Standard Deviation | Coefficients of Variation | $-\partial f/\partial \delta$ Average | Standard Deviation | Coefficients of Variation |
|---|---|---|---|---|---|---|---|---|---|
| 1[a] | 1.0 | 0.25 | 0 | 0.218 | 0.086 | 0.394 | 0.561 | 0.397 | 0.708 |
| 2 | 1.0 | 0.25 | 0 | 1.108 | 0.436 | 0.394 | 0.797 | 0.467 | 0.585 |
| 3 | 1.0 | 0.25 | 0.5 | 0.286 | 0.113 | 0.395 | 0.566 | 0.415 | 0.733 |
| 6 | 0.8 | 0.25 | 0 | 1.029 | 0.405 | 0.394 | 0.896 | 0.524 | 0.585 |
| 7 | 1.2 | 0.10 | 0 | 0.989 | 0.389 | 0.393 | 0.632 | 0.366 | 0.579 |
| 8 | 1.2 | 0.10 | 0.5 | 0.245 | 0.097 | 0.396 | 0.432 | 0.313 | 0.725 |
| 9 | 1.5 | 0 | 0 | 0.650 | 0.251 | 0.386 | 0.405 | 0.220 | 0.543 |
| 10 | 2.0 | 0 | 0 | 0.295 | 0.114 | 0.386 | 0.214 | 0.107 | 0.500 |

Note: Computed by using (4.10) and the coefficient of INT in Table 8 for the numbered regressions.
[a]Based on $\delta_r$, rather than $\delta_{ar}$.

$$= \frac{\partial \ell n(f + c_0)}{\partial \ell n(\delta - c_1)} \quad \frac{(f + c_0)}{(\delta - c_1)} \quad = b\ell n(1.1 + g_y) \quad \frac{(f + c_0)}{(\delta - c_1)}. \qquad (4.10)$$

Table 11 reports the prewar results for the elasticity of $f + c_0$ with respect to $\delta - c_1$ in terms of equation (4.9). Because $g_y$ varies from year to year, so does the elasticity coefficient, and therefore the table reports average values, standard deviations, and coefficients of variation. The elasticities in these regressions differ with the variables used but the coefficients of variations are practically the same for all the regressions shown. Table 11 also gives the values for the coefficients of $\frac{\partial f}{\partial \delta}$ obtained by using equation (4.10). The results here depend on the values of $f_t$ and $\delta_t$.

The first three regressions in Table 11 are for the $f$ series that resulted when $\lambda = 1$. There is a great similarity in the response coefficients of the $\delta_r$ and the $\delta_{ar}$ series, particularly when $c_1$ is used to correct $\delta_{ar}$. Thus, the average coefficient for the prewar $\delta$ series is 0.561 (regression 1) and that for regression 3, using $(\delta_{ar} - 0.5)$, is 0.556. When the value of $\lambda$ is changed, different values for the savings flow variable result, and therefore coefficients are different.

## Summary and Conclusions

The development of the Japanese economy was accompanied by a flow of savings from agriculture to the rest of the economy. Our measurement of this outflow was obtained by indirect calculations which depend on saving rates in the two sectors. Although these saving rates are not known, they are estimated for the prewar data. The estimates indicate that the saving rates in agriculture remained constant and relatively high and that the saving rates in the rest of the economy were lower, but increased with per capita production in that sector. The savings flow series was obtained under varying assumptions with respect to the ratio of saving rates in the two sectors.

The basic premise that was tested and empirically supported by this study is that the flow of savings can be attributed to differential returns to capital in the two sectors. The magnitude of the response of the savings flow to changes in the differential returns depends on the data series used to measure the flow and to measure differential returns. Regression 3 in Table 11 indicates that when saving rates are equal in the two sectors then $\partial f/\partial \delta = -0.566$ and when the ratio of agriculture to nonagriculture saving rates is 2, then $\partial f/\partial \delta = -0.214$, where $\delta$ is the ratio of the rate of returns to investment in agriculture to that in the rest of the economy. The difference between the two coefficients largely reflects the difference in the value of the savings flow variable under the two saving rate ratios. The prewar arithmetic average of $f$ for $\lambda = 1$ is 0.335 and that of $f$ for $\lambda = 2$ is 0.588 (see Appendix C, Table 24).

The results here were obtained from regressions in which the ratio of returns to capital ($\delta$) is measured by the ratio of the average productivities of capital. More refined data will make it possible to obtain clearer results, but until such data become available, there is no reason not to accept the present results.

Savings flows play an important role in the process of development. The flow is initiated by higher capital returns in the nonagricultural sector; that is, there are

better opportunities out of agriculture. In a static situation, the flow of savings tends to equalize returns in the two sectors, and eventually it will diminish. This process cannot be isolated from other processes, however. There is a flow of labor along with the flow of capital, and the two flows affect each other. The migration of labor out of agriculture increases the capital-labor ratio in agriculture, which reduces the rate of return on agricultural capital and increases it in the other sector. Thus, the labor migration increases the differential in returns and augments the flow of savings. By a similar argument the flow of savings augments the migration of labor. These complementary relationships between labor and savings flows imply that the low-income sector contributes to increases in both capital and labor in the high-income sector.

When dynamic changes are taken into account, the flow of savings depends on the productivity of capital, or more technically, on the capital share in the production function. In turn, the level of productivity or technology may depend on investment. If this is the case, the flow of savings need not decrease the differential in returns to capital, and there is no need to assume that static forces will eventually halt the flow of savings; it can continue for a long time. The flow eventually will exhaust itself, however, because the agricultural sector may become so small that the effect of the flow on the other sector will be relatively unimportant.

# 5

## AGRICULTURAL GROWTH IN THE CONTEXT OF ECONOMIC GROWTH

There is a considerable volume of work on the growth of the agricultural sector and its relationship to the overall growth of the economy. Some of this work is carried out on the basis of a dual economy which consists of a traditional, largely rural sector and a nontraditional, largely urban sector. It is infeasible to survey this work here; instead we concentrate on introducing the present framework.[49]

Empirical findings have indicated that various sectors of an economy grow at different rates.[50] These growth differences can result from unequal (and therefore nonunitary) income elasticities, nonzero demand elasticities, capital accumulation, and technical change. All these attributes can be accounted for within a neoclassical framework, which assumes that the economy develops through a sequence of short-run equilibria characterized by market clearing and equal factor prices.[51]

Although the qualitative results of these models have been analyzed, their empirical relevance has not been established. The fact that, in general, factor prices in agriculture are not equal to those in the other sectors of the economy has cast doubt on the "real world" utility of the models. Thus, attempts have been made to analyze the growth process under the assumption that distortions exist in factor markets.[52] This approach is subject to the same limitation as the neoclassical approach. It assumes that at any instant in time factors can be reallocated so as to correspond to a predetermined factor price differential between the two sectors. This assumption seems open to question.

The existence of a factor price differential indicates that allocation requires time and that it is not fully accomplished within the period of analysis (a year). An empirically relevant model should take this fact into account. Furthermore, the process of resource allocation should be viewed as an economic activity in which the rate of allocation depends on economic variables. This notion is related to the recognition that dynamic paths are determined by the systems.[53]

The main point of departure is the assumption that factor allocation among sectors

---

[49]For a recent literature survey on dual economies, see C. Lluch, "Theory of Development in Dual Economies: A Survey," mimeographed (Washington, D.C.: The World Bank, 1977).

[50]Simon Kuznets, "Quantitative Aspects of the Economic Growth of Nations, II: Industrial Distribution of National Product and Labor Force," *Economic Development and Cultural Change*, 5 (1957): 1-111; and *Six Lectures on Economic Growth* (Glencoe, Ill.: Free Press, 1959).

[51]Cf. Mundlak and Mosenson, "Two-Sector Model."

[52]Tropp and Mundlak, "Distortion in the Factor Market."

[53]A discussion of this point within a micro framework appears in Y. Mundlak, "On Microeconomic Theory of Distributed Lags," *The Review of Economics and Statistics* 48 (1966): 51-60.

at any given point in time is predetermined by historical events.[54] Factors move between sectors, but this movement takes time; the rate of factor mobility depends on economic variables, and so it can be estimated empirically. Thus, in a way, calendar time is introduced explicitly into the analysis. The short-run properties of this model are examined in the first five sections of this chapter. The properties of the factor markets and the flow of migration equations are treated in the sixth section, and the growth of the system is discussed in the next section.

The system is too complex to yield growth paths analytically, so they are calculated numerically, using Japanese data for the year 1905 as the starting point. The calculations depend on various parameters. The sensitivity of the growth path to some changes in these parameters is examined in the final section of this chapter.[55] The framework for the numerical solution and the initial data and parameter values are described in Appendix D.

## Supply Conditions

Assume the economy consists of two sectors and, at any given point in time, the distribution of resources between the two sectors is largely predetermined by past developments. Specifically, each of the sectors has $K_i(t)$ units of capital and $L_i(t)$ units of labor. Agriculture, in addition, has $A(t)$ units of land. The production function for each sector summarizes the technology in that sector, and it is expressed in terms of available, rather than employed, resources. That is, for agriculture,

$$Y_1(t) = F_1\{K_1(t), L_1(t), A(t), t\}, \tag{5.1}$$

and for the rest of the economy,

$$Y_2(t) = F_2\{K_2(t), L_2(t), t\}. \tag{5.2}$$

It is assumed that these production functions are first-degree homogeneous in the inputs and have positive first partial derivatives and negative second own partial derivatives. Otherwise, the functions are of general form and can change over time.

The production functions and the resource allocation summarize the supply conditions of the model. The supply conditions are distinct in both their inclusions and omissions—namely, the conditions that the value marginal productivities equal factor prices. This point is restated to emphasize an important feature of the formulation: at any given point in time factor allocation is predetermined. Consequently, for any given technology, the marginal productivities and, therefore, real factor prices are uniquely determined and have no role in the factor allocation for the instant period; they do influence the allocation in future periods. This specification, in general,

[54]In some of the important features the model is similar to the disequilibrium model discussed in Kelley, Williamson, and Cheetham, *Dualistic Economic Development*.

[55]The simulator used for solving the system is constructed in such a way as to facilitate tracing the impact of various policy measures, but these impacts are not examined here.

allows for unequal factor prices in the two sectors, a situation that has been dealt with under the topic of distortion in the factor market. The two models can be directly related, however.

Momentary equilibrium is achieved by selecting a relative price $p = p_1/p_2$ (the price of the first product in terms of the second one) that clears the commodity markets. Production ($y$) is used for investment and for final consumption. The supply of these two components in each sector is denoted by $X_i^i$ and $X_i^s$, respectively. Consequently, in agriculture,

$$Y_1 = X_1^s + X_1^i, \tag{5.3}$$

and in the rest of the economy,

$$Y_2 = X_2^s + X_2^i. \tag{5.4}$$

The investment goods for sector 1 are produced partly in that sector and partly in sector 2. Let $0 \leq \lambda(p) \leq 1$ be the proportion of $I_1$ that is produced in sector 1. The higher is $p$, the smaller is $\lambda$; hence $\lambda'(p) < 0$.[56] Investment for sector 2 is produced completely within sector 2 so that in agriculture,

$$X_1^i = \lambda(p)\, I_1, \tag{5.5}$$

and in the rest of the economy,[57]

$$X_2^i = I_2 + [1-\lambda(p)]\, pI_1. \tag{5.6}$$

Because the model assumes a closed economy, domestic savings are the only source of investment funds. It is assumed:[58]

$$S_1 = s_1 pY_1, \tag{5.7}$$

and

$$S_2 = s_2 Y_2. \tag{5.8}$$

---

[56] $\lambda(p)$ may also depend on variables other than $p$, but the dependence on $p$ is of interest here. In what follows, where no ambiguity will result, we write for simplicity $\lambda$ rather than $\lambda(p)$.

[57] For symmetry, we could assume that part of $I_2$ is produced in sector 1. For the dichotomy of agriculture and nonagriculture, this assumption is rather artificial and therefore ignored.

[58] We can start by assuming that saving rates differ by the source of income; i.e.,

The savings need not be fully invested in their sector of origin. Let $pF$ represent the value of funds flowing from sector 1 to sector 2; then

$$S_1(t) = p(t)(I_1(t)+F(t)), \tag{5.9}$$

and

$$S_2(t) = I_2(t) - P(t)F(t). \tag{5.10}$$

Combining (5.3) through (5.10),

$$X_1^I(t) = \lambda_1(p)\,[s_1Y_1(t) - F(t)], \tag{5.11}$$

and

$$X_2^I(t) = s_2Y_2(t) + p(t)T[p(t),t], \tag{5.12}$$

where $\quad T[p(t),t] = [1 - \lambda(p)]\,[s_1Y_1(t) - F(t)] + F(t)$

is the net draw of sector 1 on the supply of $Y_2$. It consists of investment goods for sector 1 and the net investment in sector 2 financed by savings generated in sector 1.

The supply conditions can now be summarized:

$$X_1^S(\,..\,) = Y_1(t) - \lambda_1(p)\,[s_1Y_1(t) - F(t)], \tag{5.13}$$

---

$$S_1 = s_Lw_1L_1 + s_K(r_1K_1 + RA),$$

and

$$S_2 = s_Lw_2L_2 + s_Kr_2K_2,$$

where

$S$ = total savings in each sector,

$w, r$ = wage and rental rates, respectively, in each sector,

$R$ = land rent, and

$s_L, s_K$ = are the saving rates for wages and profits, respectively.

Dividing through by the value of the sectoral output,

$$s_1 \equiv \frac{S_1}{PY_1} = \alpha_1 s_L + (1 - \alpha_1)s_K,$$

and

$$s_2 \equiv \frac{S_2}{Y_2} = \alpha_2 s_L + (1 - \alpha_2)s_K,$$

where

$\alpha_j$ is the labor share in the $j^{th}$ sector.

and

$$X_2^s(\,..\,) = (1-s_2)Y_2(t) - p(t)\,T\,(\,..\,), \tag{5.14}$$

where $(\,..\,) \equiv [p(t), t)]$;

and

$$\frac{\partial X_1^s(\,..\,)}{\partial p} = -\lambda_1'(p)I_1, \tag{5.15}$$

and

$$\frac{\partial X_2^s}{\partial p}(\,..\,) = -T(\,..\,) + \lambda'(p)I_1P, \tag{5.16}$$

where $\quad I_1 > 0$ implies $\dfrac{\partial X_1^s}{\partial p} > 0$ and $\dfrac{\partial X_2^s}{\partial p} < 0$.

It is to be noted that at any time $(t)$, the supply of $X_1$ for final consumption depends on production in that sector and on the proportion of investment in sector 1 produced in that sector. This proportion is monotonically declining with $p$. Therefore the supply of $X_1$ for final consumption increases with $p$.[59] The supply of $X_2$ for final consumption is negatively affected by the draw of sector 1, and the magnitude of this effect depends on $p$.

## Final Demand

The formulation of final demand follows that of Mundlak and Mosenson.[60] Let $x_j^d \equiv X_j^d/L$ be per capita demand in both sectors for final consumption of product $j$, and $y = py_1 + y_2$, $(y_j = Y_j/L)$ be per capita income. We can then write the demand equations,

$$x_1^d = D_1(p,y), \tag{5.17}$$

and

$$x_2^d = D_2(p,y), \tag{5.18}$$

[59]It is independent of $p$ when $\lambda(p)$ is constant. This includes the extreme case, $\lambda = 0$, in which all investment goods used by agriculture are produced by the nonagricultural sector. This was the assumption used in Mundlak and Mosenson "Two-Sector Model." It is also possible to have $\lambda = 1$; however, this case is of less interest here.

[60]Mundlak and Mosenson, "Two-Sector Model."

where

$D_j(p,0) = 0$, $D_j(p,y) > 0$ for all $0 < p < \infty$ and $y > 0$.

Now, let $E_{jp}$ and $E_{jy}$ represent the price and income elasticities, respectively, of the $j_{th}$ product. For all admissible values of $p$ and $y$, $E_{1p} < 0$, $E_{2p} > 0$, and $E_{jy} > 0$. Under the last assumption, that income elasticities are positive,[61] (5.17) and (5.18) can be combined to yield

$$x_1^d = D(p,x_2^d), \tag{5.19}$$

$$\text{with} \quad \eta \equiv \frac{\partial \ln x_1}{\partial \ln x_2} = \frac{E_{1y}}{E_{2y}} > 0, \quad \text{and} \quad -\sigma_D = \frac{\partial \ln x_1^d}{\partial \ln p} = E_{1p} - \eta E_{2p} < 0.$$

It should be noted that demand is not differentiated by sectors; differences in consumption patterns between sectors are attributed to differences in income.[62]

## Momentary and Comparative Equilibria

Equilibrium is achieved by selecting a price that equates aggregate sectoral demand with sectoral production. This is the same as equating supply and demand for final consumption; that is

$$x_j^d(\,.\,.\,) = x_j^s(\,.\,.\,) \equiv x_j, \tag{5.20}$$

where $x_j^s \equiv X_j^s/L$. Using (5.20) for $x_1^d$, the demand equation (5.19), subject to its restrictions, can be written as

$$x_2^d = D^*(p,x_1). \tag{5.21}$$

If the excess demand function is defined as

$$\phi(\,.\,.\,) = D^*\,[p(t),x_1^s(\,.\,.\,)] - x_2^s(\,.\,.\,),$$

then, using the conditions on the demand function and equations (5.15) and (5.16) we have for $I_1 \geqslant 0$:

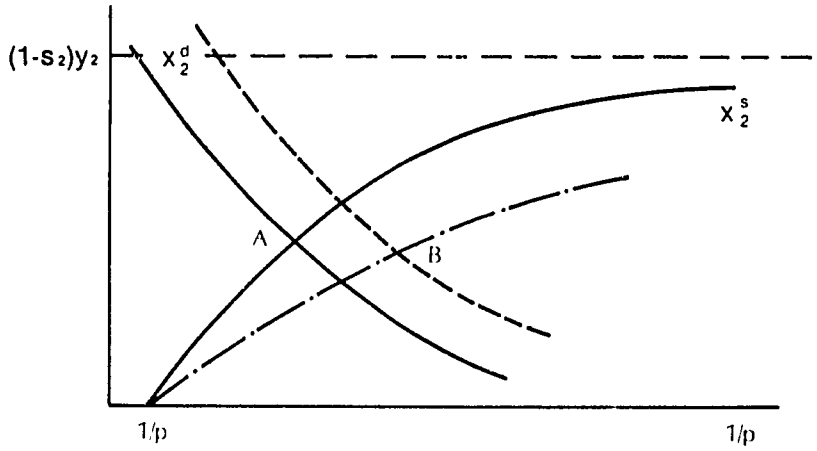
$$\frac{\partial \phi(\,.\,.\,)}{\partial (1/p)} = \underset{(-)}{\partial x_2^d/\partial (1/p)} - \underset{(-)}{\partial x_2^s/\partial (1/p)} < 0. \tag{5.22}$$

[61]Extending the argument to nonnegative elasticities is rather a straightforward matter but somewhat cumbersome in presentation.

[62]In a more realistic model, differences in prices between sectors should also be allowed for. Such differences also contribute to differences in consumption.

The solution is illustrated in the figure below:

**Figure 4. Momentary Equilibrium Determination**




The momentary equilibrium determines the price $p(t)$; point $A$ in the figure represents the initial such equilibrium point. Reference to the figure indicates that variations in the various exogenous variables or parameters affect $p(t)$ by affecting either the demand or the supply for $x_i(t)$. The effect of changes in the demand or the supply of $x_i(t)$ on $p(t)$ are largely signed in the following:

| *Changes in:* | $x_1^s(t)$ | $x_1^d(t)$ | $p(t)$ | $x_2^s$ | $x_2^d(t)$ |
|---|---|---|---|---|---|
| $y_1(t)$ | + | − | − | − | + |
| $y_2(t)$ | − | + | + | + | − |
| $f(t)$ | + | − | − | − | + |
| $s_1$ | − | − | ? | − | − |
| $s_2$ | 0 | − | − | − | 0 |
| $\lambda$ | − | + | + | + | − |

For instance, an increase of per capita production in sector 1 increases the investment in the sector. Some of the capital goods for sector 1 are purchased from sector 2, and consequently less of $y_2$ is available for final consumption, and $x_2^s$ declines. At the same time, $x_1^s$ increases and, by the demand condition, $x_2^d$ increases. This is because of the income effect of an increase in $y_1$. Thus, the excess demand increases and $1/P$ increases (recall that $p_2$ is the numeraire), or $p$ declines.

Point $B$ in the figure represents such a change. The initial increase in $y_1(t)$ can result either from an increase in that sector's resources or from a change in technology. In tracing the effect of a change in $y_1$, $f$ was considered to be fixed. In the discussion of

the flow equation in Chapter 4, and below, it is stated that $\partial f/\partial(s_2y_1) > 0$, $\partial f/\partial(s_2y_2) > 0$. This condition augments the effect just considered.

To this condition we can also add a quantitative assumption, $\partial I_1/\partial(s_1y_1) > 0$, $\partial I_2/\partial(s_2y_2) > 0$. Under these assumptions, $\partial T/\partial(s_2y_2) > 0$ $\partial T/\partial(s_1y_1) > 0$. With these conditions, the table can be completed. This simple framework makes it possible to trace the effects of various factors and variables on prices, $p(t)$. Changes in $p(t)$ have further repercussions on the system, and those are discussed next.

## Factor Markets

The distribution of inputs between sectors determines their marginal productivities. Once the price is determined, we also have the value marginal productivities. Thus, for agriculture,

$$\begin{aligned} w_1(t) &= p(t)F_{1L}, \\ r_1(t) &= p(t)F_{1K}, \\ R &= p(t)F_{1A}, \end{aligned} \tag{5.23}$$

and for the rest of the economy

$$\begin{aligned} w_2(t) &= F_{2L}, \\ r_2(t) &= F_{2K}, \end{aligned} \tag{5.24}$$

where

$w,r$ = wage and rental rates, respectively, in each sector,

$R$ = rent on land, and

$F_{ji}(i = L,K,A)$ = the marginal productivities evaluated for the given inputs and technology at time $t$.

The factor prices need not be equal. They are now endogenous to the system, and so are their ratios; that is, $\delta_r \equiv r_1/r_2$ and $\delta_w \equiv w_1/w_2$. It is possible to analyze the economy under the assumption that such ratios are constant, but other than one.[63] The approach in such an analysis is somewhat different than the present one. The supply conditions consist of defining all the resource allocations that result in a given level of distortion in the factor markets. The equilibrium solutions consist of those allocations that result in market clearance. Thus, the distortion analysis can be considered somewhat a dual analysis to the present one; that is, a solution to the present model is a solution to a factor price distortion analysis, and vice versa. Clearly, however, once it is admitted that resource allocation is largely determined by histori-

[63]Tropp and Mundlak, "Distortion in the Factor Market."

cal events, the equilibrium approach to the analysis of distortion in the factor market loses much of its relevance for empirical analysis.

The essence of the present analysis is that the allocation of factors between sectors takes time. More specifically, there is a flow of resources between the sectors. There is a difference between the flow of capital and that of labor. It is assumed that the value of the capital flow is bounded by the value of savings in the sector of origin. Only gross investment can be allocated. In contrast, the flow of labor can exceed growth in the labor force. Let $M(t)$ be the migration of labor from sector 1 to 2 and $n_1$ be the natural rate of population growth in sector 1; then,

$$M(t) = (1 + n_1)L_1(t) - L_1(t + 1). \tag{5.25}$$

The labor flow variable $M(t)$ and the flow of funds $F(t)$ can be considered as functions of variables whose values are determined by the state of the economy at time t and by expectations with respect to the future. Such functions were estimated empirically in Chapters 2 to 4. The flow variables can also, within bounds, be considered in development models as instrumental or policy variables.

On the basis of Chapter 2,

$$m(t) = \frac{M(t)}{L_1(t)} = \left[\frac{L_2(t)}{L_1(t)}\right]^{\beta_{1m}} m^*[\delta_w^*(t), z(t)], \tag{5.26}$$

where

$0 < \beta_{1m} < 1$, $z$ = various exogenous variables, including policy instruments, and

$\delta_w^*$ = expectation at $t$ about the ratio of the wage rates in the two sectors.[64]

A similar approach was followed in Chapter 4 with respect to the flow of funds; that is,[65]

$$\frac{p(t)F(t)}{S_1(t)} = \left[\frac{\pi_2(t-1)}{\pi_1(t-1)}\right]^{\beta_{11}} f^*[\delta_r^*(t), z(t)], \tag{5.27}$$

where the $\pi(t)$ are the proportion that each sector's income is of total income, and $z(t)$ is a set of exogenous variables. Note that both (5.26) and (5.27) are formulated so as to maintain "constant returns to scale;" that is, doubling the labor force in the economy, while holding the relative allocation and the other variables unchanged, will leave $m(t)$ unchanged. A similar interpretation follows for the flow equation.

---

[64]In empirical analysis it is preferable to use the ratio of income per capita in each of the two sectors rather than the ratio of wages (Chapter 2). This, however, is not important for the present discussion.

[65]Actually, $\pi_2/\pi_1$, is used as a proxy for $S_2/S_1$. This point is discussed in Chapter 4.

## The Growth of the System

The system defining the momentary equilibrium consists of equations (5.1) through (5.10), (5.19), and (5.20). The system is expected to change constantly because of the growth of resources, changes in their allocation—as given in (5.26) and (5.27)—and changes in technology.

The change in the sectoral capital stock is given by $\hat{K}_i = I_i/K_i - \Delta$, where $\Delta$ is the depreciation rate. Drawing upon equations (5.7) through (5.10),

$$\hat{K}_1 = s_1 Y_1/K_1 - F/K_1 - \Delta, \tag{5.28}$$

and

$$\hat{K}_2 = s_2 Y_2/K_2 + pF/K_2 - \Delta. \tag{5.29}$$

Labor is assumed to grow at exogenously determined rates $n_i$. Taking into account labor migration, (5.25) and (5.26), we obtain for the growth in the labor force

$$\hat{L}_1 = n_1 - m, \tag{5.30}$$

*and*

$$\hat{L}_2 = n_2 + m(\ell/1 - \ell), \tag{5.31}$$

where $\ell = L_1/L$.

Technical change can take various forms. Part of the value of the exercise is to trace the consequences of various forms of technical change on the growth pattern. The problem begins with the empirical applications, in which the evidence is generally not sufficiently rich. We can write for the effect of technical change on output

$$\hat{Y}_1\Big|_{K_1, L_1, A} = \alpha_1\gamma_{1L} + \beta_1\gamma_{1K} + (1-\alpha_1-\beta_1)\,\gamma_{1A} \equiv \gamma_1, \tag{5.32}$$

and

$$\hat{Y}_2\Big|_{K_2, L_2} = \alpha_2\gamma_{2L} + \beta_2\,\gamma_{2K} \equiv \gamma_2, \tag{5.33}$$

where $\gamma_{jL}$ is the rate of increase in the efficiency of labor in each sector.

Given equations (5.26) and (5.27) and the various parameters in question, equations (5.28) through (5.33) and the production functions determine the rates of change of sectoral outputs, $Y_i$. To express such changes on a per capita basis, we need

$$\hat{L} = n_1\,\ell + n_2(1-\ell). \tag{5.34}$$

Changes in outputs are allocated between changes in final consumption and changes in investment. To obtain the change in final uses, it is necessary to differentiate equations (5.3) through (5.10) with respect to time. Bringing in the differentials of (5.19) and (5.20), the rates of change of the various components of the system can be expressed in terms of the predetermined variables, including migration, flow of funds, and the rate of change in the flow of funds. If, however, expectations with respect to differential sectoral income or factor returns are related to current factor returns, the system is not quite closed.

To solve for the rates of change of the various components, we need the rates of change of factor returns and some assumptions about how they affect the formulation of expectations. In the numerical illustration that follows,it is assumed that these expectations are naive: that is, that current factor prices are expected to continue. The sensitivity of the growth process to this assumption is of interest, but it is not discussed here.

Factor prices are determined by (5.23) and (5.24). In addition to the explicit roles they play in flow equations (5.26) and (5.27), they play an implicit role in the computation of factor shares. That requires an explanation. The production functions described by (5.1) and (5.2) are quite general and need not be closely specified. We need to know the rates of change of the outputs with time, but for this it is sufficient to know the production elasticities. Thus, the problem of specifying a production function is reduced to that of specifying the marginal productivities.[66] Furthermore, for any set of initial values, all that is needed is the rates of change in the marginal productivity conditions. Thus,

$$\hat{w}_1 - \hat{p} = \hat{F}_{1L},\ \hat{r}_1 - \hat{p} = \hat{F}_{1K},\ \hat{R} - \hat{p} = \hat{F}_{1A}, \tag{5.35}$$

and

$$\hat{w}_2 = \hat{F}_{2L},\ \hat{r}_2 = \hat{F}_{2K}. \tag{5.36}$$

It should be recalled, however, that marginal productivities cannot change freely because, by assuming constant returns to scale, they are subject to the Euler equation. Differentiating the Euler equation and substituting factor prices for value marginal productivities,[67]

$$\gamma_1 = \alpha_1\hat{w}_1 + \beta_1\hat{r}_1 + (1-\alpha_1-\beta_1)\,\hat{R} - \hat{p}, \tag{5.37}$$

and

$$\gamma_2 = \alpha_2\hat{w}_2 + (1-\alpha_2)\,\hat{r}_2. \tag{5.38}$$

[66]This has important econometric implications which are not fully recognized and which will be discussed elsewhere.

[67]These are the rates of change in the cost functions and could be obtained from different points of view.

Thus, for practical application, the rates of change of the marginal productivities have to be specified. In the applications of this model, we chose the constant elasticity of substitution (CES) form. The results are summarized in a compact form in Appendix D.

## Some Numerical Illustrations

In the present model, analytic solutions of growth paths are infeasible, and one has to resort to numerical solutions.[68] By its very nature, a numerical solution is specific to the choices of data and parameters. Inductive generalizations for a relevant choice of data and parameters are possible but are not of immediate importance. Therefore, we will confine our numerical examination of the performance of the model to situations of direct interest.

We have selected Japan of 1905 as our initial point in order to illustrate the calculation of growth paths, to point out some relationships among the endogenous variables along these paths, and to examine the sensitivity of the paths to changes in the parameters. In so doing, we compare results obtained under alternative assumptions.

This is not a discussion of the Japanese experience as such—a subject which will be treated in Chapter 6; it is a methodological analysis. We, therefore, will not explain and justify the choice of the values used for the parameters. The essence of the method is described in Appendix D, and the initial data and parameters are described in Appendix E.

We consider several alternative growth paths, but it would require too much space to present the entire paths for all variables in question. Instead, we present results for the initial year, $t = 1$, and for $t = 21$. The results are summarized in Table 12.[69]

The first column of Table 12 reviews the results of the basic run. The basic run is obtained under the assumption that in the initial year ($t = 1$) sector 1 experiences technical change of 1.52 percent, population growth of 1.3 percent, and a migration rate of 2.8 percent. The migration rate increases to 3.5 percent in $t = 21$.[70] As a consequence, the sector 1 labor force declines from 16.2 in $t = 1$ to 11.7 in $t = 21$, and per capita production declines from 18.3 to 16.4. The decline in sector 1's per capita supply and the increase in real income result in an increase in the price ratio to the level of 1.9. Factor prices in sector 1 increase because of the increase in $p$, the technical change, and, in the case of labor, the decline in labor intensity caused by migration. To eliminate the price effect, factor prices are also reported in terms of sector 1's product.

The sectoral gap in wages causes labor migration. In order to trace the effect of

---

[68]Cf. Kelley, Williamson, and Cheetham, *Dualistic Economic Development;* and Houthakker, "Disproportional Growth."

[69]In this analysis $\lambda$ is treated as exogenous. Also, savings flow is restricted so as to be independent of the differential returns. This restriction is removed in the next chapter.

[70]These rates are higher than the actual prewar rates, and the reader who is interested in the Japanese experience should keep it in mind. This is discussed further with the results for lower migration rates.

## Table 12—Numerical solutions—selected results for t = 21

| Variable | $t = 1$* | $t = 21$: Basic run and modifications (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) | (21) | (22) | (23) | (24) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $Y_1/L=y_1$ | 18.3 | 16.4 | 19.7 | 21.1 | 16.9 | 15.6 | 18.8 | 20.2 | 18.2 | 16.9 | 19.2 | 22.0 | 16.2 | 32.3 | 16.6 | 14.4 | 14.7 | 16.7 | 16.3 | 16.6 | 16.4 | 16.3 | 16.9 | 16.2 | 17.0 |
| $Y_2/L=y_2$ | 40 | 106 | 89 | 81 | 103 | 110 | 94 | 86 | 106 | 106 | 106 | 107 | 146 | 122 | 97 | 107 | 99 | 107 | 124 | 112 | 106 | 106 | 105 | 107 | 104 |
| $L_1$ | 16.2 | 11.1 | 15.6 | 17.6 | 11.8 | 10.2 | 14.3 | 16.3 | 11.0 | 11.1 | 11.0 | 10.9 | 10.9 | 15.3 | 14.6 | 11.2 | 14.7 | 11.2 | 10.9 | 11.0 | 11.3 | 11.1 | 11.7 | 10.8 | 11.8 |
| $L_2$ | 8.8 | 21.3 | 16.8 | 14.8 | 20.6 | 22.2 | 18.1 | 16.1 | 21.4 | 21.3 | 21.4 | 21.5 | 21.5 | 17.1 | 22.4 | 25.8 | 27.0 | 21.2 | 21.4 | 21.3 | 21.1 | 21.2 | 20.6 | 21.5 | 20.5 |
| $K_1$ | 3679 | 3668 | 3840 | 3907 | 3701 | 3608 | 3789 | 3864 | 3764 | 3697 | 3821 | 3960 | 3663 | 4435 | 3805 | 3667 | 3804 | 4343 | 3664 | 4289 | 3663 | 3666 | 3685 | 3660 | 3688 |
| $K_2$ | 4242 | 10808 | 9799 | 9380 | 10614 | 11153 | 10112 | 9653 | 10804 | 10807 | 10795 | 10791 | 12545 | 11242 | 10993 | 11623 | 11810 | 11031 | 15493 | 12289 | 10803 | 10807 | 10878 | 10788 | 10894 |
| $p$ | 1 | 1.9 | 1.3 | 1.1 | 1.8 | 2.1 | 1.4 | 1.2 | 1.6 | 1.8 | 1.5 | 1.2 | 2.3 | 7 | 1.8 | 2.3 | 2.2 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 2.8 | 1.6 | 3.0 |
| $w_1$ | 29 | 89 | 53 | 44 | 82 | 100 | 61 | 50 | 82 | 87 | 83 | 75 | 106 | 47 | 75 | 109 | 92 | 92 | 91 | 91 | 96 | 92 | 129 | 74 | 137 |
| $w_2$ | 122 | 175 | 189 | 197 | 177 | 174 | 184 | 191 | 175 | 175 | 175 | 174 | 244 | 260 | 172 | 164 | 161 | 177 | 211 | 187 | 174 | 174 | 179 | 174 | 179 |
| $r_1$ | .025 | .056 | .043 | .038 | .054 | .061 | .046 | .041 | .051 | .057 | .048 | .044 | .067 | .033 | .058 | .070 | .071 | .052 | .057 | .051 | .053 | .055 | .086 | .046 | .099 |
| $r_2$ | .187 | .250 | .225 | .212 | .248 | .252 | .233 | .221 | .251 | .250 | .251 | .250 | .291 | .267 | .256 | .274 | .280 | .246 | .189 | .228 | .253 | .250 | .240 | .253 | .242 |
| R | 54 | 107 | 84 | 76 | 103 | 114 | 90 | 81 | 104 | 105 | 95 | 89 | 127 | 72 | 113 | 134 | 139 | 112 | 109 | 109 | 96 | 103 | 164 | 88 | 176 |
| $k_1$ | 227 | 330 | 246 | 222 | 314 | 355 | 265 | 237 | 342 | 334 | 347 | 365 | 336 | 291 | 260 | 327 | 258 | 389 | 335 | 389 | 328 | 329 | 314 | 338 | 311 |
| $k_2$ | 482 | 508 | 585 | 634 | 516 | 502 | 559 | 600 | 506 | 507 | 505 | 502 | 584 | 657 | 492 | 450 | 437 | 520 | 723 | 576 | 510 | 509 | 527 | 501 | 531 |
| $\ell$ | .65 | .34 | .48 | .54 | .36 | .31 | .44 | .56 | .34 | .34 | .34 | .34 | .34 | .47 | .40 | .30 | .35 | .34 | .34 | .34 | .35 | .34 | .36 | .33 | .37 |
| $\rho$ | .46 | .39 | .33 | .31 | .38 | .40 | .35 | .33 | .36 | .38 | .34 | .30 | .40 | .21 | .38 | .43 | .41 | .43 | .31 | .40 | .39 | .39 | .49 | .35 | .51 |
| $\pi$ | .31 | .23 | .22 | .22 | .22 | .23 | .22 | .22 | .21 | .22 | .21 | .20 | .20 | .14 | .23 | .24 | .24 | .23 | .20 | .22 | .23 | .23 | .31 | .19 | .33 |
| $w_1/p$ | 29 | 47 | 42 | 40 | 46 | 48 | 43 | 41 | 52 | 48 | 57 | 64 | 47 | 71 | 43 | 46 | 42 | 48 | 47 | 48 | 50 | 48 | 46 | 48 | 45 |
| $r_1/p$ | .025 | .030 | .033 | .035 | .030 | .029 | .033 | .034 | .032 | .032 | .033 | .038 | .030 | .049 | .033 | .032 | .033 | .026 | .030 | .027 | .028 | .029 | .030 | .030 | .030 |
| $R/p$ | 54 | 57 | 66 | 70 | 58 | 55 | 64 | 68 | 65 | 58 | 65 | 76 | 56 | 110 | 64 | 56 | 64 | 58 | 56 | 57 | 50 | 54 | 58 | 56 | 58 |
| $pk_1$ | 227 | 625 | 313 | 242 | 557 | 737 | 378 | 286 | 547 | 599 | 509 | 429 | 759 | 192 | 459 | 768 | 558 | 756 | 649 | 740 | 625 | 625 | 888 | 527 | 936 |
| $pk_1/k_2$ | .47 | 1.23 | .54 | .38 | 1.08 | 1.47 | .68 | .48 | 1.10 | 1.20 | 1.01 | .85 | 1.30 | .29 | .93 | 1.71 | 1.28 | 1.45 | .90 | 1.28 | 1.23 | 1.23 | 1.69 | 1.05 | 1.80 |
| $m$ | .028 | .035 | .016 | .010 | .034 | .033 | .019 | .014 | .036 | .036 | .036 | .038 | .037 | .019 | .034 | .033 | .033 | .035 | .038 | .036 | .034 | .034 | .028 | .038 | .027 |
| $\delta_m(t)$ | | 1.07 | .33 | .19 | 1.16 | .93 | .43 | .28 | .96 | 1.04 | 1.00 | .88 | .88 | .11 | .74 | .99 | .98 | 1.06 | .73 | 1.05 | 1.04 | .95 | 1.03 | .86 | 1.07 |
| $(t)$ | | (51) | (51) | (51) | (51) | (51) | (51) | (51) | (51) | (51) | (51) | (51) | (51) | (51) | (51) | (31) | (41) | (51) | (51) | (51) | (41) | (41) | (31) | (51) | (31) |

*The units of measurement for the following variables are: $y_1$, $K_1$, $k$, $w_1/p$, $R/p$, and $r_1$. They are measured in terms of the sector 1 product; $y_2$, $K_2$, $w_1$, $w_2$, $r_1$, and $pk_1$, are measured in terms of the sector 2 product; $r_2$ and $r_1/p$ are pure numbers.

[b] The columns represent various parameter assumptions. The changes for each column are:

(1) The basic run; data for this run are described in Appendix E.
(2) $b_{0m}$, the intercept of the migration equation is $-4.5$ instead of $-3.755$.
(3) $b_{0m}$ is $-5$.
(4) The slope of the wage differential in the migration equation, $b_{2m}$, is 0.1 instead of 0.232.
(5) $b_{2m} = 0.5$.
(6) $b_{0m} = -4.5\, b_{2m} = 0.5$.
(7) $b_{0m} = -5$, $b_{2m} = 0.1$.
(8) Land-augmenting technical change in sector 1, $\gamma_{1A}$, is 0.03 instead of 0.0152.
(9) Capital-augmenting technical change in sector 1, $\gamma_{1K}$, is 0.03 instead of 0.0152.
(10) Labor-augmenting technical change in sector 1, $\gamma_{1L}$, is 0.03 instead of 0.0152.
(11) $\gamma_{1A} = \gamma_{1K} = \gamma_{1L} = 0.03$.
(12) $\gamma_{2L} = \gamma_{2K} = 0.03$, instead of 0.0167.
(13) $b_{0m} = -4.5$, $\gamma_{1A} = \gamma_{1K} = \gamma_{1L} = 0.04$, $\gamma_{2L} = \gamma_{2K} = 0.03$.
(14) Natural rate of growth in sector 1, $n_1$, is 0.026 instead of 0.013.
(15) $n_2 = 0.026$ instead of 0.013.
(16) $n_1 = n_2 = 0.026$.
(17) The saving ratio in sector 1, $s_1$, grows at the rate of 3 percent ($\dot{s}_1 = 0.03$) instead of zero growth.
(18) $\dot{s}_2 = 0.03$ instead of $\dot{s}_2 = 0$.
(19) Depreciation rate, $\Delta$, is 0.02 instead of 0.03.
(20) The direct elasticities of substitution in the two sectors are reversed in size: $\sigma_1 = 0.8$, $\sigma_2 = 1.2$.
(21) $\sigma_1 = \sigma_2 = 1$.
(22) The "income elasticity", $\eta$, is 0.6 instead of 0.3.
(23) The "demand elasticity" $-\sigma_D =$ is 0.9 instead of $-0.6$.
(24) $-\sigma_D = 0.3$.

labor migration on factor prices, we present the value of $\delta_w = w_1/w_2$ for a specified year in the distant future. Thus, at $t = 51$, $\delta_w = 1.07$; that is, the agricultural wage rate slightly exceeds the nonagricultural wage. For the same year, the rental on capital in agriculture still lags behind that in the nonagricultural sector.

The effect of labor migration on factor intensity is reflected in the capital-labor ratios, and, in general, there is a faster capital deepening in agriculture. Capital in sector 1 is reported in terms of that sector's product. To make it comparable with the capital of the nonagricultural sector, it is multiplied by $p$ to yield $pk_1$, and this product is compared with $k_2$ by computing, $pk_1/k_2$. The ratio increases from 0.47 in $t = 1$ to 1.23 in $t = 21$, indicating that sector 1 has become more capital intensive. In the present run, this is largely an outcome of rapid labor migration and the restricted mobility of capital, which results in relatively low returns on capital in agriculture.

Finally, the relative importance of sector 1 is reflected in its share in the labor force ($\ell$), the overall capital stock ($\rho$), and total output ($\pi$). Obviously, the sharpest decline was in $\ell$, from 0.65 to 0.34.

We can now evaluate some of the effects of the parametric changes. First, we consider two kinds of changes in migration: in the level of the migration equation; and in the slope, or elasticity, with respect to the wage differential. The actual equation used was taken from Chapter 3; that is,

$$m = \exp\left[-3.755 + .232 \ln\left(\frac{w_2}{w_1} - 0.85\right) + 0.372 \ln\left(\frac{L_2}{L_1}\right) + 10.88 \ln(1 + n)\right]. \quad (5.39)$$

This equation was obtained by finding the intercept (in this case, $b_{0m} = -3.755$) that will best fit the Japanese data for 1951-72 if the other coefficients are obtained from CCS analysis.

The postwar period has been a period of intensive migration, and therefore the intercept obtained may be relatively large; $exp - 3.75 = .0235$, so even without the contribution of any other terms we get a migration rate of 2.35 percent, which is somewhat high for the period under consideration. Columns 2 and 3 in Table 12 report results for lower migration rates: the intercepts are $exp - 4.5 = 0.011$ in column 2 and $exp - 5 = 0.0067$ in column 3. A comparison of the two columns indicates that reducing migration rates causes the per capita product in sector 1 to increase instead of decline as it did in the basic run. This is because with less migration, more of the labor force remains in agriculture. Also, because part of sector 1's savings are invested in that sector, smaller migration leads to large total savings accumulation in sector 1, but these "extra" savings are not enough to match the larger labor force. Therefore, the capital-labor ratio decreases as migration decreases.

The smaller migration is, the smaller is the pressure on prices from the supply side. Also, smaller migration reduces per capita production in sector 2, and, therefore, puts less pressure on $p$ from the demand side. The values of $p$ at $t = 21$ are 1.27 for $b_{0m} = -4.5$ and 1.09 for $b_{0m} = -0.5$. The factor prices reflect the changes in factor intensities. A decrease in migration decreases $k_1$ and increases $r_1/p$, the real return on

capital. However, since $p$ also decreases, $r_1$, the rate of return evaluated at "current prices," decreases with a decline in migration. The behavior of real wages is in the opposite direction. As a consequence, the smaller is the migration, the larger is the intersectoral wage differential. Obviously, the amount and the rate of closure of the wage differential depend on the rate of migration.

Table 13 summarizes the effect of these parametric changes by presenting the signs of the changes along the growth path. Column $b_{0m}$ for example, summarizes the direction effect of changes in the level of the migration equation. Columns 4 and 5 of Table 12 report results due to changes in the slopes of the wage differential in the migration equation; instead of 0.232, used in the basic run, there is a decline to 0.1 in column 4 and an increase to 0.5 in column 5. Basically, increasing the slope increases migration, and consequently the direction of changes along the growth path are similar to those obtained by changing the intercept. This can be seen by comparing columns $b_{0m}$ and $b_{2m}$ of Table 13.

Various forms of technical change are considered in columns 8 to 13 of Table 12. In the basic run, each of the technical change components in sector 1 is 1.52 percent and in sector 2, 1.67 percent. Increasing each component in sector 1 separately to 3 percent increases output; the total increase in output is weighted by the particular factor share. Again, an increase in sector 1 output is accompanied by a decline in $p$ as compared with the basic run and by a decline in factor prices in sector 1. However, the real values of factor prices (deflated by $p$) rise because of the technical change. These changes are relatively small, and therefore they do not affect migration rates.

A more pronounced effect is obtained when all the components of the agricultural technical change are allowed to change by 3 percent: this leads to larger agricultural output, lower $p$ (1.18), lower $w_1$ (75), and therefore a somewhat larger migration rate, 3.8 percent in $t = 21$. The wage ratio is still less than 1 in $t = 51$. The directional effects of changing all the components appear in column $\gamma_1$ of Table 13. Column 12 in Table 12 reports results for a technical change of 3 percent in sector 2. In that case, $p$ goes up, indicating that the relative price of nonagricultural output declines. The directional effects of increasing $\gamma_2$ are reported in Table 13.

In most of the various runs, per capita agricultural product either declines with time or increases slightly. This is because of strong migration, and only moderate technical change as compared with population growth. Column 13 in Table 12 is an exception—it assumes a 4 percent technical change in sector 1, 3 percent in sector 2, and a small migration rate; this results in a per capita production of 32.3 in $t = 21$, compared with 18.3 in the base year.

The remaining columns can be reviewed in a similar way. Columns 14, 15, and 16 report changes because of the doubling of the natural rates of population growth to 2.6 percent in one or both sectors. Total population increases at faster rates, and any per capita figures are thus lower. Otherwise, the increase in the differential rates of population growth affect product prices and factor prices as expected; factor intensities are affected similarly (but not independently).

In columns 17 and 18, the saving rates are allowed to increase every year at the rate of 3 percent; in column 19, the depreciation rate is decreased from 3 to 2 percent. These changes directly affect the capital stock. It is obvious that because of the

## Table 13—Directional effects of parametric changes along growth path

| Variables | Parameters[a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $b_{0m}$ | $b_{2m}$ | $\gamma_1$ | $\gamma_2$ | $n_1$ | $n_2$ | $s_1$ | $s_2$ | $\eta$ | $\sigma_D$ |
| $y_1$ | − | − | + | − | + | − | + | − | + | − |
| $y_2$ | + | + | + | + | − | + | + | + | − | + |
| $L_1$ | − | − | − | − | + | + | + | − | + | − |
| $L_2$ | + | + | + | + | + | + | − | + | − | + |
| $K_1$ | − | − | + | − | + | 0 | + | − | + | − |
| $K_2$ | + | + | − | + | + | + | + | + | + | − |
| $p$ | + | + | − | + | − | + | 0 | 0 | + | − |
| $w_1$ | + | + | − | + | − | + | + | + | + | − |
| $w_2$ | − | − | 0 | + | − | − | + | + | + | − |
| $r_1$ | + | + | − | + | + | + | − | + | + | − |
| $r_2$ | + | + | 0 | + | + | + | − | − | − | + |
| R | + | + | − | + | + | + | + | + | + | − |
| $k_1$ | + | + | + | + | − | + | + | + | − | + |
| $k_2$ | − | − | − | + | − | − | + | + | + | - |
| $t$ | − | − | 0 | 0 | + | − | 0 | 0 | + | − |
| $\rho$ | + | + | − | + | − | + | + | − | + | − |
| $\pi$ | + | + | [illegible] | − | 0 | + | 0 | − | + | − |
| $w_1/p$ | + | + | + | 0 | − | − | + | 0 | − | + |
| $r_1/p$ | − | − | + | 0 | + | + | − | 0 | 0 | 0 |
| $R/p$ | − | − | + | 0 | + | − | + | − | + | − |
| $pk_1/k_2$ | + | + | − | + | − | + | + | − | + | − |

Note: 0 signifies no effect, while − and + signify negative and positive effects respectively.

[a]The direction of changes is obtained by comparing changes in different columns of Table 12 as follows:

$b_{0m}$ — From columns (1), (2) and (3).
$b_{2m}$ — From columns (1), (4), and (5).
$\gamma_1$ — From columns (1), (4), and (5).
$\gamma_2$ — From columns (1) and (12).
$n_1$ — From columns (1) and (14).
$n_2$ — From columns (1) and (15).
$s_1$ — From columns (1) and (17).
$s_2$ — From columns (1) and (18).
$\eta$ — From columns (1) and (22).
$\sigma_D$ — From columns (1), (23) and (24).

restriction on the mobility of capital funds the sector in which savings increase is important.

The presentations in columns 20 and 21 of Table 12 indicate that the results are not very sensitive to the choice of the elasticity of substitution. The effect of the elasticity of substitution on growth is only of second-order importance. One result, however, is that the effect on prices also is not substantial. This may explain why many analysts have not succeeded in obtaining empirically "proper" values for elasticities of substitution.[71]

[71]It should be noted that the values of $\sigma_i$ which appear in the table are only the initial values. The model allows for changes in $\sigma_i$ with time. These changes, however, were not large in most cases.

The last three columns report results due to changes in demand parameters. Increasing the "income elasticity," $\eta$, from 0.3 to 0.6 increases the demand for the sector 1 product that results from higher real income arising from technical change and capital accumulation. The increase in demand increases $p$ and factor prices in sector 1, and consequently the migration rate is reduced somewhat.

Changing the "price elasticity" from −0.6 to −0.9 and to −0.3 has a significant effect on $p$, on factor prices, on the migration rate, and on relative capital intensity. When $p$ increases along the growth path, as in the present case, increasing the (absolute value of the) price elasticity implies a decline in the quantity demanded of sector 1's product. As a consequence, the directional effect on the system should be the opposite of the effect of increasing income elasticity. This is indeed the case here, as can be seen by comparing the last two columns of Table 13.

A different way to interpret Table 13 is to read the rows and examine the causes for a particular change in the endogenous variables. This is left for the reader with one exception. As argued elsewhere, the proper measure of the terms of trade of agriculture is the return on its specific factors;[72] in this case, the return on land as measured by $R$. Changes in $R$ originate in changes in $p$ and in real rent. Real rent is measured by $R/p$, or the share of land in the average (per unit of land) productivity. Average productivity increases with factor intensity and with technical change. The effect of $p$ depends on the values of $p$. Most of the runs indicate upward pressures on sector 1's $p$, and this contributes to an increase in $R$. However, in a situation where $p$ declines, such as in run 13, the price effect is to suppress considerably the rent measured in "value" terms. Obviously, with less elastic demand, technical change in sector 1 may result in actually reducing rent.

The lack of immediate factor mobility implies that a change generated in one market does not spread immediately to other markets. This can be seen in Table 12. The degree of rigidity is determined by the rates of factor flow, but these in turn are considered to be economic variables. Yet, policy measures that can speed up flow also assist in spreading the effect among the various markets.

Eventually, if factor mobility is greater than a minimal rate, equality of factor prices is achieved. That may take a long time, even when the annual migration accounts for 3 percent of the labor force. However, once the point of equality is reached, analytic results obtained from neoclassical models, which assume equality of factor prices, are pertinent and should not differ from the results obtained from the present model.

Our analysis here raises an important methodological issue. These runs have been obtained by changing a small number of parameters—in many cases only one parameter. It is clear that there is a great deal of freedom in creating various forms of growth paths. Furthermore, a particular path can be created by more than one set of parameters. How, then, can a reconstruction of a particular history be used as evidence that the "right" set of parameters has been used?

Obviously, this is a problem of identification in a somewhat different context. If the system is identified, then in principle it should be possible to estimate the parameters

---

[72] Y. Mundlak, "The Terms of Trade of Agriculture in Context of Economic Growth" in *Economic Problems of Agriculture in Industrial Societies*, eds. U. Papi and C. Nunn. (New York: St. Martin's Press, 1965), pp. 634-56.

in some optimal sense by using nonlinear techniques. Although this subject is outside the mainstream of our analysis, it is important to emphasize that, in general, there are no one-to-one onto relations between a set of parameters and a growth path. Therefore, reconstructing a historical growth path from a particular set of parameters, or more generally by using a particular model, does not prove that this model is the true or correct one. It is legitimate, however, to use the procedure we have demonstrated; that is, to evaluate the response of the growth path to a particular change in parameters.

# 6

## A QUANTITATIVE INTERPRETATION OF SOME ASPECTS OF THE JAPANESE EXPERIENCE

During the last century, Japan has been transformed from a largely rural and backward economy to a major industrial economy.[73] "Perhaps the most outstanding feature of Japan's development is its rapidity, or what is even more important, the sustained character of the growth process."[74]

### The Growth Process in Japan

Because of its growth record, the Japanese experience has been broadly investigated. Various approaches have been tried. First, there are the simplistic views, the single concept or criterion framework. For instance, there is some preoccupation with the concept of the prerequisite for growth. Did Japan grow because it met the prerequisite, established by the British experience, that an agricultural revolution must precede the industrial revolution?

Ohkawa states that "so far as agriculture is concerned, this notion seems to be not applicable to the Japanese case."[75] Instead, "the point is that Japanese agriculture developed . . . side by side with the process of speedy industrialization—a concurrent growth of industry and agriculture."[76] This interpretation is in line with Gerschenkron's idea that prerequisites have substitutes.[77] That, of course, raises the question of the usefulness of the concept of prerequisites.

Basically, growth originates in using existing resources better as well as in adding to available resources. Adding resources and improving technology can be a purely domestic activity or one assisted by the outside world. The growth process can be accomplished in various ways, through various combinations, and at various rates. It is more instructive, therefore, to study the process itself rather than to select a particular aspect of it and try to generalize from it. Indeed, Hayami *et al.*, after examining various lessons drawn from the Japanese experience, conclude that "the lessons from the Japanese experience, if any, should be the process by which a unique pattern of agricultural and economic development was created in exploiting

---

[73]"We chose 1868, the year of the Meiji Restoration, as the point of departure for modern economic growth in Japan." K. Ohkawa. *Differential Structure and Agriculture: Essays on Dualistic Growth* (Tokyo: Kinokuniya Bookstore Co., 1972) p. 166.

[74]Ohkawa and Rosovsky "The Role of Agriculture," pp. 43-57.

[75]Ohkawa, *Differential Structure*, p. 167.

[76]*Ibid.*, p. 170.

[77]A. Gerschenkron *Economic Backwardness in Historical Perspective* (Cambridge: Harvard University Press, 1962) pp. 31-5 .

the available opportunities specific to Japan. . . ."[78]

Several writers have studied various aspects of Japan's growth process.[79] All contributors seem to agree on the main features of the process, such as the role of agriculture in financing investments for industrialization, in providing food for increased demand, and in supplying cheap labor to the other sectors of the economy.[80] Different analysts vary in the weights they give to different features of the process. Most of the discussions, though based on empirical evidence, do not quantify the process in the way that was outlined in Chapter 5. It is desirable, therefore, to supplement the literature by fitting our model to the Japanese data to see how the process can be examined in its entirety within the framework we have proposed. This analysis can be used to quantify the effects of some of the features of Japan's growth process.

The next section of this chapter reviews briefly some of the highlights of the Japanese experience. It is followed by two sections which describe how the model is fitted to prewar and postwar Japanese data. Next, the role of intersectoral resource flow is examined quantitatively. The approach is to obtain the development paths of the economy without labor migration, without a flow of savings from agriculture, then without either of the two. A similar approach is followed in examining the importance of technical change and rates of capital accumulation. In so doing, light is cast on the quantitive importance of these features.

## Growth in Agriculture

Various studies indicate an overall growth of Japanese agriculture for a long span of time. Yamada and Hayami state that the average annual rate of growth in agriculture for the period 1880 to 1965 was 1.6 percent.[81] They divide this period into subperiods which differ in the growth rates of agricultural output, as well as in some other economic attributes. The growth rate subperiods are:

I—1876-1904 (1.2 percent), a period of steady growth.
II—1904-18 (3.5 percent), a period of accelerated growth.
III—1918-38 (0.9 percent), a period of relative stagnation.
IV—1938-47 (2.8 percent), the war period.
V—1947-57 (4.4 percent), the postwar recovery.
VI—1957-67 (2.8 percent), spurt following the recovery.

The growth in output was accompanied by a slower increase in aggregate input.

---

[78]Hayami *et al. A Century of Agricultural Growth*, p. 215.

[79]Ohkawa and Rosovsky, "The Role of Agriculture," and Ohkawa, "Agricultural Policy."

[80]Gustav Ranis, "The Financing of Japanese Economic Development," in *Economic Growth and Agriculture*.

[81]S. Yamada and Y. Hayami, "Growth Rates of Japanese Agriculture, 1880-1965," mimeographed, (The Food Institute, East-West Centre, University of Hawaii, and Economic Development Center, University of Minnesota, 1972). Similar results are also reported in Hayami *et al.*, *A Century of Agricultural Growth*.

Yamada and Hayami attribute 40 percent of the overall increase in output (or value added) to an increase in aggregate input; the remaining 60 percent was attributed to the residual, technical change; that is, of the 1.6 percent increase in agricultural output, 0.6 percent can be attributed to aggregate input and about 1 percent to technical change.

The input trend reflected a decline in agricultural labor from a level of 16 million workers in 1907 to about 14.5 million in 1937; this decline was subject to some fluctuations related to overall economic activity. In the 1950s the labor force was again 16 million, reflecting the return to agriculture during the war years, but in the postwar period this level went down to nearly 10 million workers in the late 1960s, and it has continued to decline throughout the 1970s.

Other agricultural inputs increased. Land increased by 30 percent during the whole period; capital increased slowly in the prewar period and rather rapidly in the postwar period, and inputs of raw materials, such as fertilizers, also increased.[82] Hayami, *et al.* claim that the technical change was partly due to nonconventional inputs, such as education and research; to a smaller degree, however, the change reflected a statistical point related to the selection of proper weights.[83] It is important to note here that the interwar period was basically a period of stagnation in technical change.[84]

## Growth in Other Sectors

The nonagricultural sector experienced more rapid growth than the agricultural sector. This, in part, reflects the growth of resources in the N sector. The growth of the labor force consisted of the natural rate of increase, as well as the migration of labor from agriculture. (See Figure 6.) The N labor force increased from a level of 9 million workers in 1907 to 17 million in 1937, a near doubling of the labor force. The situation in the postwar period was even more remarkable. The labor force increased from 24 million workers in 1955 to 42 million workers in 1969.

It is generally agreed that the flow of labor from the A sector is a response to changing economic opportunities. There is less agreement on the nature of the economic opportunities. The lack of consensus to a large degree reflects difficulties in measuring the factors related to the migration. In Chapter 3, we show that migration from agriculture into another sector can be explained in terms of income differentials between the two. These income differentials are themselves endogenous to the process of growth.

It is interesting to note that despite the differential rate of growth of output of the two sectors, agricultural prices did not increase much relative to other prices during the entire survey period; in fact, throughout a good part of it, they declined. Figure 10 shows that for the prewar period the ratio of agricultural prices to N sector prices went up from 1 in 1907 to 1.1 in 1922. It declined thereafter, reaching its lowest value of .68 in 1932. In part, the decline reflects the fact that domestic agricultural production was

---

[82]The detailed time paths of output, capital, and labor are shown in Figures 4, 6, and 8.

[83]Hayami *et al.*, *A Century of Agricultural Growth*, chapter 4.

[84]*Ibid.*, chapter 5.

not the only source of supply; it was supplemented by food imports. Imports became important following the food riots of 1918.[85]

In the postwar period, using the 1955 ratio of prices as a base, we see that agricultural prices declined up to 1960, and from then on there is a general trend toward price increases reaching a level of about 1.2 in 1969 (see Figure 13). This perhaps indicates a relative scarcity of agricultural products. A higher relative price for A sector products acts to close the gap in per capita income between the two sectors and to discourage off-farm migration.

Although this may have been the case in recent years and is the prospect for the future, it was not true of prewar Japan. In that period, the relative price of agricultural products did not show a significant upward trend, and the income differential was considerable That is an indication that the rate of off-farm labor migration was not high enough offset the effect of the natural rate of labor force growth on agricultural incomes. Only in more recent years has this trend reversed, tending to narrow the intersectoral income differential.

Some writers have emphasized, in addition to the flow of labor, the importance of the flow of savings out of agriculture in financing growth of the nonagricultural sector. The quantitative effect of such a flow has not been discussed explicitly, at least not in sufficient detail, in the literature. Even though on a priori grounds one can agree with the qualitative aspect of this argument, it is difficult to nail down the quantitative effect of the flow of savings. Some of these issues were explored in Chapter 4, and some measures of the flow itself were developed in order to estimate the quantitative effect of the variables that determine such a flow. This analysis suggested a gap in returns and an outflow of up to 40 percent of agricultural savings in the prewar years. The outflow declined in the postwar years, and recently it has been disappearing.

In brief, the two sectors have grown at different rates, and agriculture has contributed labor and capital to the nonagricultural sector, but has managed to maintain its overall per capita growth by technical change. The flow of resources has been motivated by income differentials, which in turn reflect factor scarcity, as well as the levels and the changes in the levels of technology in the two sectors. Thus income differentials are endogenous to the process of development.

A theory or framework for analyzing this process requires a system which explains the behavior of all these variables simultaneously. The approach outlined in Chapter 5 will be used here to explain or simulate the Japanese experience we have just reviewed.

## Fitting the Model: Prewar Data

Obtaining numerical solutions to Japan's growth path requires making assumptions about the values of the parameters which enter into the model. Appendix F lists all the variables that enter the analysis and their initial values for the prewar (1907) and postwar (1955) periods.[86] Some of the more important assumptions involved labor

---

[85] *Ibid.*, pp. 61-64.

[86] It should be noted that we use five-year moving averages to fit the data and for the simulation. We did

and savings flows. For off-farm labor migration we use the empirical results obtained in Chapter 3. The migration equation was fitted separately to the prewar and postwar data so as to obtain intercepts for the two subperiods that are consistent with the fact that migration was much slower in the prewar than in the postwar period. The actual values used for the intercepts were −3.785 percent and −4.8 for the prewar and postwar years, respectively.[87] Otherwise, the empirical equation is the same as the one used in Chapter 5.

The flow of savings equation that is used is:

$$dln\ (F/S_1) = -0.17 dln\ (S_2/S_1) - 0.091\ dln\delta_r$$

Unlike labor migration, the initial values for the savings flow must conform to national accounting identities for the base years. For all other years, the values were obtained by deriving the rates of change of the flow variable using the flow equation The intercept does not enter into this derivation.

Savings flows cannot be analyzed independently of knowledge of, or assumptions about, saving behavior in the two sectors. Estimates of the sectoral saving rates and their effect on the estimates of the rates of flow were taken up in Chapter 4. Prewar saving rates in agriculture were estimated to be about 20 percent. The saving rate of the N sector increased steadily as a function of per capita income in that sector, starting from a level of 9 percent in 1907 and reaching 16 percent in 1937. Using these values in the simulation yielded accumulation rates which were somewhat below the actual rates, so the saving rates for the prewar period were adjusted up moderately.

Factor shares for agriculture reported by Yamada and Hayami indicate a low value about 0.1 for the capital share, a land share of about 0.3, with the labor share accounting for the remaining 0.6.[88] The shares for the N sector were taken from Ohkawa and Rosovsky. The initial value for the labor share is slightly less than 0.6. The value changes throughout the period because the shares are endogenous in this analysis, and they are computed for every year according to the simulated results for that particular year.

The initial values for technical change in the two sectors were obtained from the same sources as the factor shares. However, these values were adjusted to improve the fit of the model.

Initially, the analysis was carried out under the assumption of a residual technical change in A of 1.1 percent per year and of 0.75 percent per year in N. The results are reported in Table 14 under the headings of Run 1 for 1920 and for 1937. The actual values are reported also for purposes of comparison. The values were obtained for all years and were plotted against the actual values.

In general, the fit of the simulated values to the data was "good." The exception was

---

not have a comprehensive set of annual data for years prior to 1905. Working with five-year averages, the analysis starts with 1907.

[87]The reference here is to the intercept in the logarithmic form of the equation. The respective natural values are: 0.0082 and .0227.

[88]Yamada and Hayami, "Growth Rates of Japanese Agriculture," Appendix. In some runs we tried some different values, but those are not reported here.

**Table 14—Actual and simulated levels of some economic variables for prewar Japan**

| Variable[a] | Initial Values: 1907 | 1920 | | | 1937 | | |
|---|---|---|---|---|---|---|---|
| | | Actual Values | Run 1[c] | Run 2[d] | Actual Values[b] | Run 1[c] | Run 2[d] |
| $y_1$ | 25.8 | 27.6 | 25.8 | 28.1 | 25.2 | 25.7 | 23.8 |
| $y_2$ | 45.9 | 71.0 | 67.1 | 67.1 | 105.6 | 108.4 | 101.1 |
| $L_1$ | 16.1 | 14.8 | 15.6 | 15.6 | 14.5 | 14.4 | 14.5 |
| $L_2$ | 9.1 | 12.5 | 12.2 | 12.2 | 17.2 | 17.1 | 17.1 |
| $K_1$ | 3.9 | 4.5 | 4.4 | 4.5 | 5.7 | 5.8 | 5.8 |
| $K_2$ | 5.0 | 11.7 | 9.7 | 9.7 | 24.8 | 24.8 | 24.1 |
| $P$ | 1.0 | 1.12 | 1.03 | 0.96 | 0.91 | 1.07 | 1.11 |
| $w_1$ | 42.6 | | 53.1 | 53.9 | | 72.0 | 69.8 |
| $w_2$ | 138.2 | | 185.4 | 185.5 | | 283.1 | 263.9 |
| $r_1$ | 3.4 | | 3.7 | 3.7 | | 3.8 | 3.7 |
| $r_2$ | 18.7 | | 15.5 | 15.7 | | 10.8 | 10.5 |
| $R$ | 76.6 | | 86.2 | 87.5 | | 99.7 | 96.7 |
| $k_1$ | 2.4 | 3.1 | 2.8 | 2.9 | 4.0 | 4.0 | 4.0 |
| $k_2$ | 5.4 | 9.4 | 7.9 | 7.9 | 14.4 | 14.5 | 14.1 |
| $t$ | 0.638 | 0.542 | 0.600 | 0.560 | 0.458 | 0.457 | 0.458 |
| $p$ | 0.440 | 0.277 | 0.321 | 0.309 | 0.188 | 0.199 | 0.212 |
| $\pi$ | 0.360 | 0.280 | 0.284 | 0.287 | 0.193 | 0.202 | 0.208 |
| $w_1/P$ | 42.6 | | 51.6 | 56.2 | | 67.6 | 62.7 |
| $r_1/P$ | 3.4 | | 3.6 | 3.9 | | 3.6 | 3.3 |
| $Pk_1$ | 2.4 | | 2.9 | 2.8 | | 4.2 | 4.5 |
| $Pk_1/k_2$ | 0.447 | | 0.371 | 0.351 | | 0.294 | 0.317 |
| $m$ | 0.9 | 1.6 | 1.1 | 1.1 | 1.2 | 1.3 | 1.3 |

Note: Empty cells indicate that data were not available.

[a]Units of variables are as follows (monetary values in constant 1907 yen):

$y_1, y_2$ — yen
$L_1, L_2$ — millions of workers
$K_1, K_2$ — billions of yen
$w_1, w_2$ — yen
$r_1, r_2$ — percent
R — yen
$k_1, k_2$ — hundred yen
$r_1, p$ — percent
$pk_1$ — hundred yen
$m$ — percent

[b]Actual values are five-year moving averages centered at indicated year. Empty cells indicate no comparable data were available.

[c]Run 1 is the basic prewar simulation run.

[d]Run 2 divides the prewar into subperiods 1907 to 1920, 1920 to 1937. For the first subperiod $\gamma_1$ is set at 0.0175. For the latter subperiod $\gamma_1$ is 0.0015 and $\gamma_2$ is 0.004. Otherwise, the values of the initial data and parameters are the same as in the basic run.

per capita agricultural production, for which the simulated path did not pick the turning point in 1918. This may have been because the rate of technical change was greater during the first part of the period.

Run 2 accounts for this difference by assuming a residual technical change in agriculture of 1.75 percent per year for 1907 to 1920 and only 0.15 percent per year for the remaining prewar years. Similarly, to get a better fit for nonagricultural output, the rate of technical change was reduced from .75 percent to .40 percent for the second subperiod.

The results of Run 2 are plotted in Figures 5 through 9. The simulated per capita agricultural output values shown in Figure 5 fit the actual values reasonably well. In particular, the model simulates the turning point and the interwar retardation.[89] Attributing the turning point to technical change does not reveal many factors, but at this level of aggregation we do not go into a more refined explanation of this term. Our main interest is to examine how the assumptions with respect to the parameters of the model help us to explain the overall observed trends in the main economic variables. The figure shows similar results for the nonagricultural sector. Here, there is a much stronger trend in the data, and this trend is well depicted by the simulated results.

In Figure 6, we see that agricultural labor declined constantly, except for some cyclical fluctuations during the period. This trend is depicted by the simulated results, but the simulation does not pick up the cyclical variations. An even better fit of the simulated results to the data is obtained with respect to the N labor force.

Capital accumulation in each sector is shown in Figure 7, and again the simulated results come close to the actual values. The simulation would come even closer if the saving rate in agriculture were increased somewhat.

Figure 8 traces the trend, or rather the fluctuations in the ratio of nonagricultural to agricultural prices. It is apparent that the price ratio fluctuated a great deal during this period. The simulated path detects some of the trend in the data, reflecting during the first part of the period a relative scarcity of agricultural compared to nonagricultural outputs and a later reversal of this situation.[90]

There are no good data for wages to be compared with the simulated results, but it is of some interest to compare the simulated wage rates in the two sectors, and this is done in the top panel of Figure 9. The comparison shows that the gap in wage rates widens in the prewar period, which indicates that migration out of agriculture was not fast enough to decrease the relative oversupply of labor in agriculture.

The situation is somewhat different with regard to returns on capital shown in the lower panel. The return to capital in the N sector declined rather fast, reflecting the rapid capital accumulation, whereas the rate of return in agriculture increased only slightly. As a result, the differential returns on capital declined during the prewar period.[91]

---

[89]The period covered by the prewar simulation covers periods II and III in the classification of Yamada and Hayami discussed previously.

[90]The model is basically a closed economy model, but net imports can and were introduced exogenously. Apparently, this procedure was not sufficiently refined to produce the observed annual price variations.

[91]On the whole, the rate of returns in agriculture are rather low. These low returns reflect the base data,

**Figure 5. Actual and Simulated Per Capita Outputs, Prewar Period**

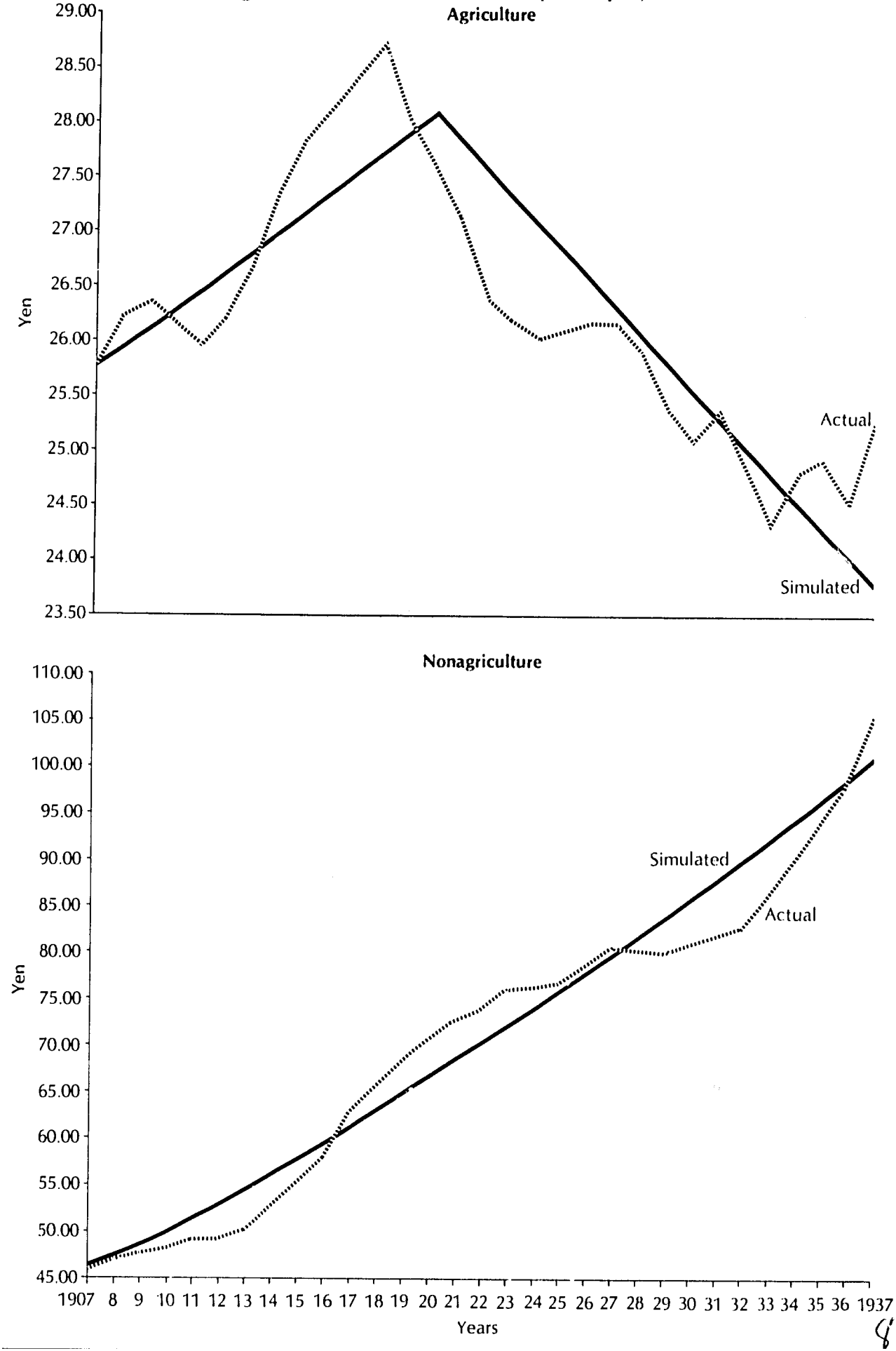


Figure 6. Actual and Simulated Labor Force Levels, Prewar Period

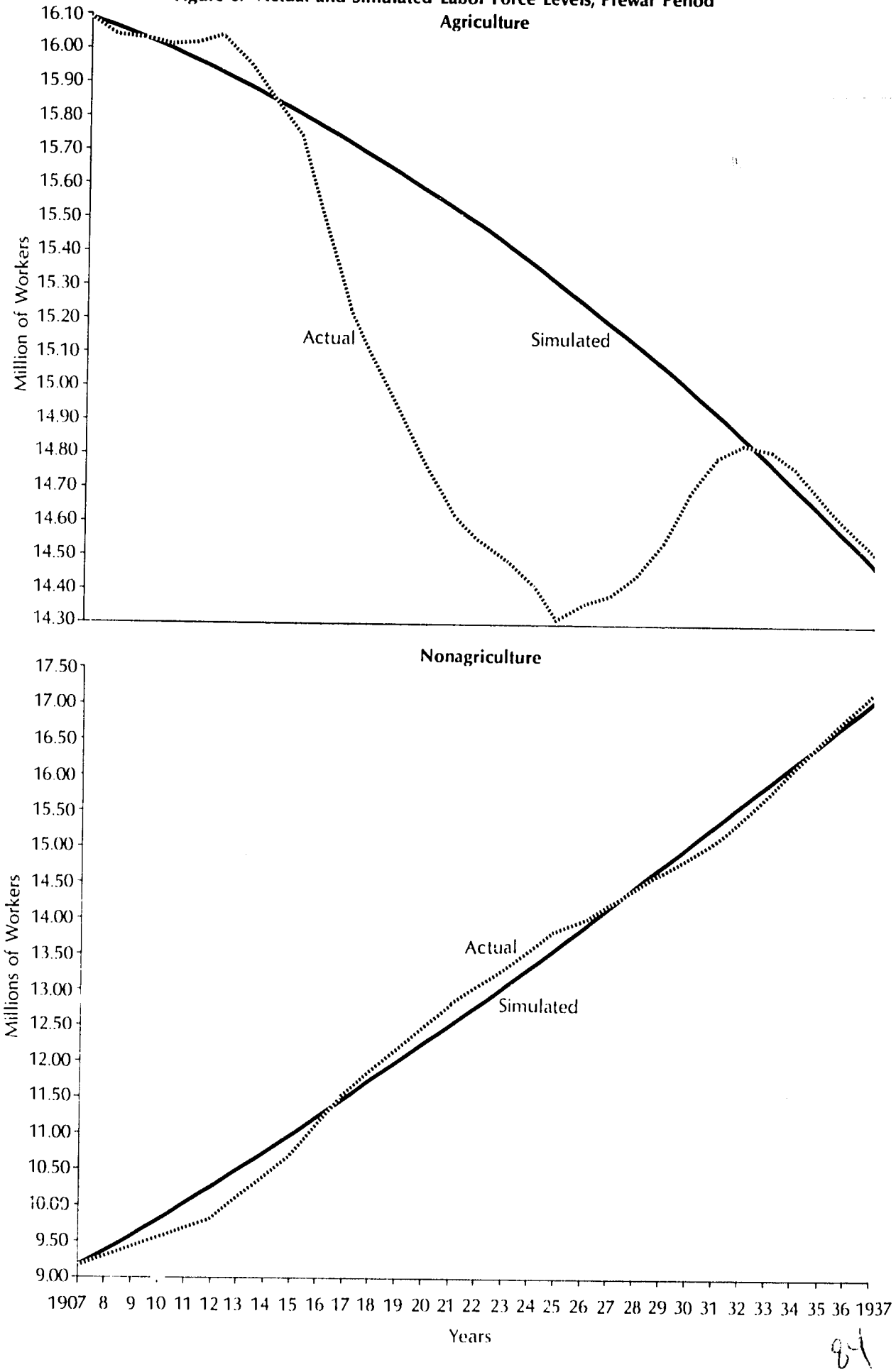


**Figure 7. Actual and Simulated Capital, Prewar Period**

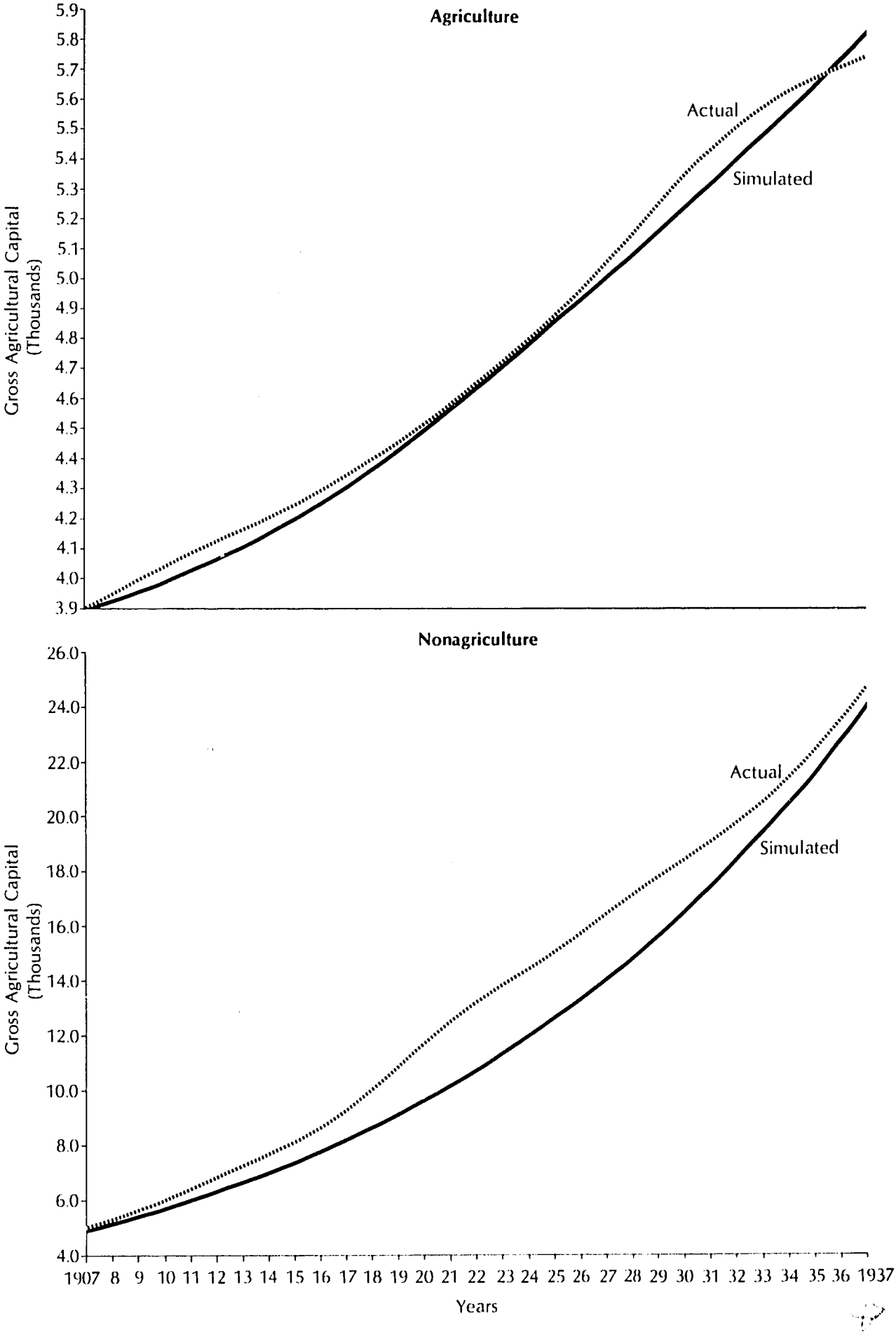


Figure 8. Actual and Simulated Terms of Trade Between Agricultural and Nonagricultural Sectors, Prewar Period

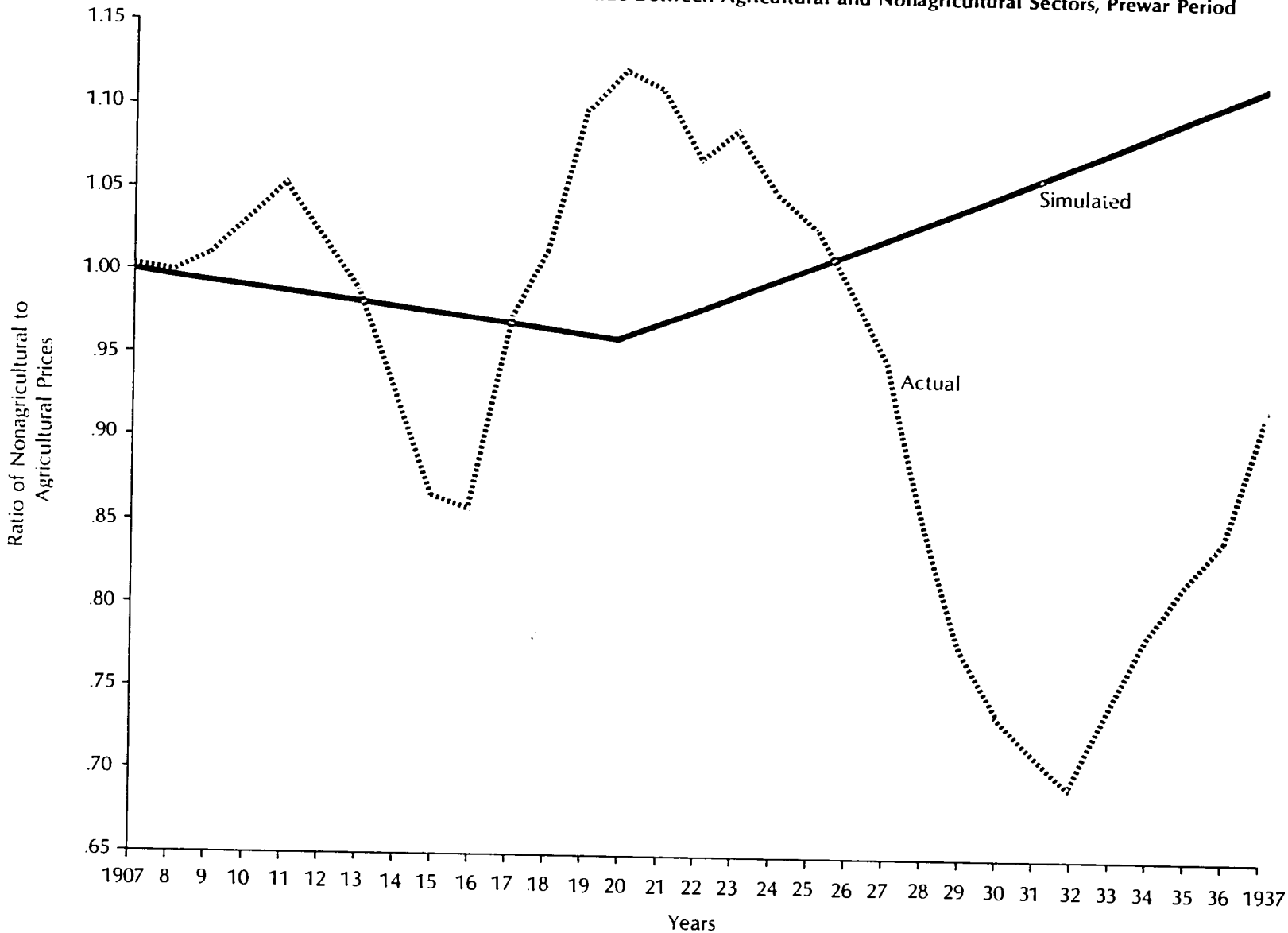
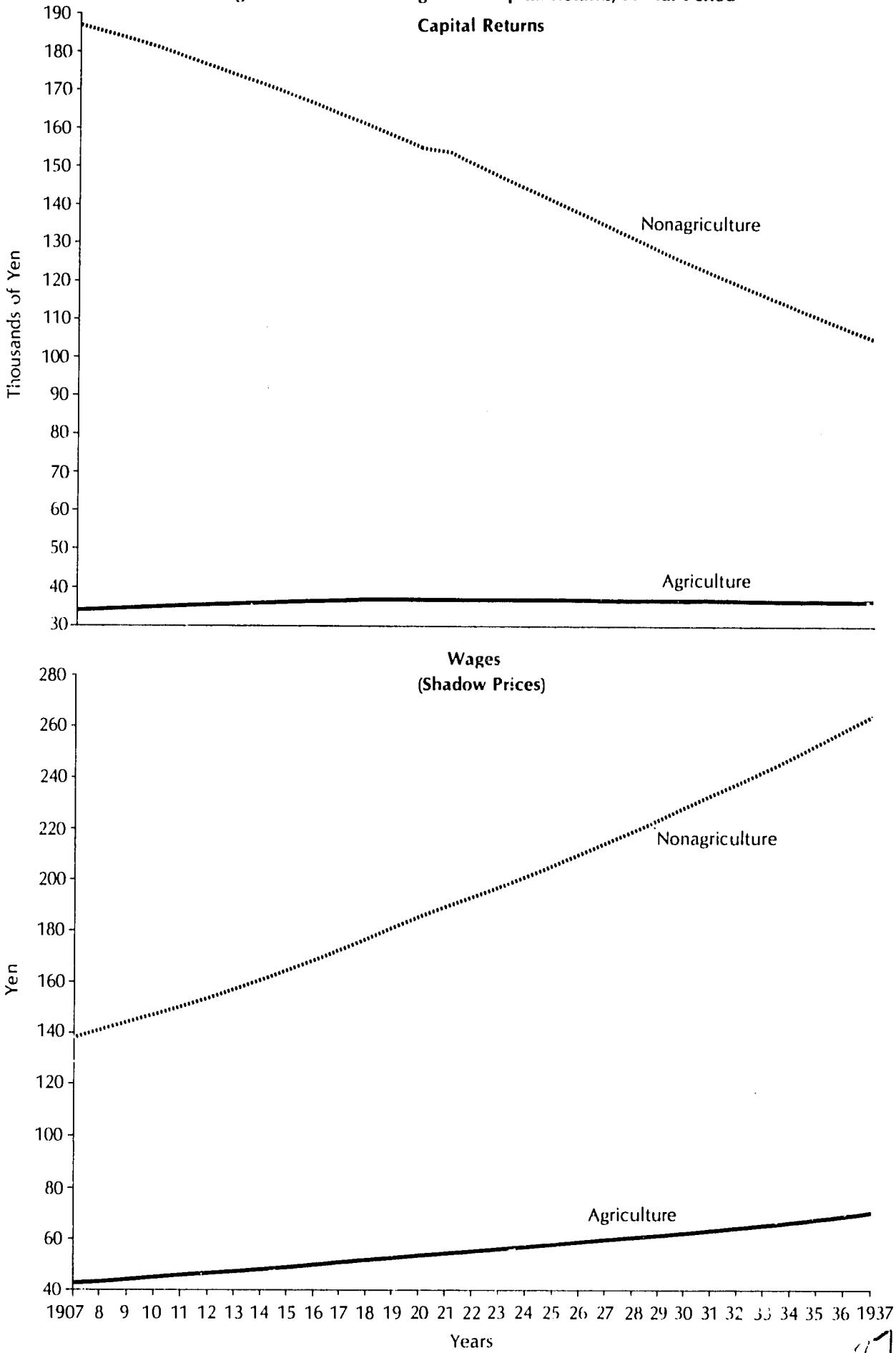


Figure 9. Simulated Wages and Capital Returns, Prewar Period



## Fitting the Model: Postwar Data

One of the reasons given for the high growth rates of the postwar period is the rapid capital accumulation resulting from high saving rates. To take this source into account, we select initial values of .33 and .25 respectively, for the A and N saving rates. The rates are increased constantly until in 1969 they reach .43 for the A and .38 for the N sector. Our empirical analysis of the postwar data detected the dependence of saving rates on income. Although the simulator can accommodate such dependence, the relationship was simply ignored, and rates of change in the saving ratios were imposed exogenously.

The considerably higher migration rate in the postwar than in the prewar years was introduced into the simulation by selecting a higher value for the intercept of the postwar migration equation. The rates of technical change for the postwar period were also considerably different from the values used for the prewar years. For agriculture, we used a value of 4 percent a year, and for the nonagricultural sector, we used a value of 5.25 percent a year. Consequently, it is assumed that the growth in production is attributable to rapid capital accumulation and a rapid increase in the level of productivity. However, there is another source for increase in production in the N sector—the flow of savings from the agricultural sector.

The values of the variables relevant to Japanese growth are summarized for the initial year 1955 and for years 1962 and 1968 in Table 15. The simulated results and actual data for the postwar year appear in Figures 10 through 14. By and large, the fit for the postwar period is even better than that obtained for the prewar period.

Again, the main differences between the simulated data and the actual data are in variables which fluctuate; in the postwar years, that means fluctuations around trend lines. For example, the top panel of Figure 10 shows annual or cyclic fluctuations around the simulated trend line which represents the overall increase in the agricultural per capita output. The other variable which shows fluctuations is the price ratio, shown in Figure 13. The simulation model does not take into account factors which lead to the decline in the price ratio in the period 1963-67. Yet, the two price ratio series, simulated and actual, are subject to an overall upward trend, and they converge in 1967.

The analysis demonstrates that this model fits the Japanese data with a good deal of precision. Further modifying some of the parameters or dividing the period could improve the fit, but the purposes of this analysis are not particularly advanced by such refinements. These results have nothing new to offer in terms of the qualitative phenomenon of Japanese development. However, they do provide quantitative estimates of the importance of the relative variables and offer a framework for analyzing the importance of assumptions about parameter values in explaining Japan's development. The model of the Japanese experience may be used to analyze some of the broader and more important issues of economic development in general.

---

which are derived from the capital shares. The capital shares are taken from Yamada and Hayami. It seems that some further experimentation with the value of capital shares, and thereby with the rate of return in agriculture, might be instructive.

## Table 15—Actual and simulated levels of some economic variables for postwar Japan

| Variable[a] | Initial Values 1955 | 1962 | | 1968 | |
|---|---|---|---|---|---|
| | | Actual Values[b] | Simulated Values | Actual Values[b] | Simulated Values |
| $y_1$ | 13.5 | 14.9 | 15.0 | 16.3 | 16.0 |
| $y_2$ | 77.3 | 146.7 | 146.0 | 263.3 | 249.5 |
| $L_1$ | 16.3 | 13.5 | 13.1 | 10.7 | 10.3 |
| $L_2$ | 24.8 | 32.1 | 32.5 | 39.9 | 39.6 |
| $K_1$ | 6.2 | 8.3 | 8.4 | 11.6 | 11.0 |
| $K_2$ | 18.8 | 36.8 | 36.1 | 72.2 | 70.5 |
| P | 1.0 | .95 | 1.09 | 1.20 | 1.20 |
| $w_1$ | 47.5 | | 74.3 | | 114.1 |
| $w_2$ | 206.9 | | 332.7 | | 515.3 |
| $r_1$ | 2.3 | | 2.4 | | 2.4 |
| $r_2$ | 9.3 | | 9.2 | | 7.6 |
| R | 47.5 | | 62.7 | | 79.8 |
| $k_1$ | 3.8 | 6.1 | 6.4 | 11.1 | 10.7 |
| $k_2$ | 7.6 | 11.5 | 11.1 | 18.1 | 17.8 |
| $t$ | .396 | .296 | .287 | .211 | .206 |
| $\rho$ | .247 | .184 | .202 | .139 | .157 |
| $\pi$ | .149 | .092 | .100 | .058 | .071 |
| $w_1/P$ | 47.5 | | 68.4 | | 95.4 |
| $r_1/P$ | 2.3 | | 2.2 | | ? |
| $Pk_1$ | 3.8 | | 7.0 | | 12.8 |
| $Pk_1/k_2$ | .501 | | .628 | | .722 |
| $m$ | 4.2 | 4.7 | 5.1 | 5.5 | 6.0 |

Note: Empty cells indicate that data were not available.

[a]Units of variables are as follows, with monetary values in constant 1955 yen:

$y_1, y_2$ — thousand yen
$L_1, L_2$ — millions
$K_1, K_2$ — trillion yen
$w_1, w_2$ — thousand yen
$\gamma_1, \gamma_2$ — percent
R — thousand yen
$k_1, k_2$ — hundred thousand yen
$w_1/P$ — thousand yen
$r_1/P$ — percent
$Pk_1$ — hundred thousand yen
$m$ — percent

[b]Actual values are five-year moving averages centered on year shown.

## The Role of Resource Flow

In historical perspective, the decline in the relative importance of agriculture in mature economies is a recent phenomenon. In fact, most countries are still in the early stages of development, and agriculture is their major economic sector. The importance of resource flow between the two sectors in the process of development is qualitatively well known. In the process of growth, agriculture contributes labor

**Figure 10. Actual and Simulated Per Capita Outputs, Postwar Period**

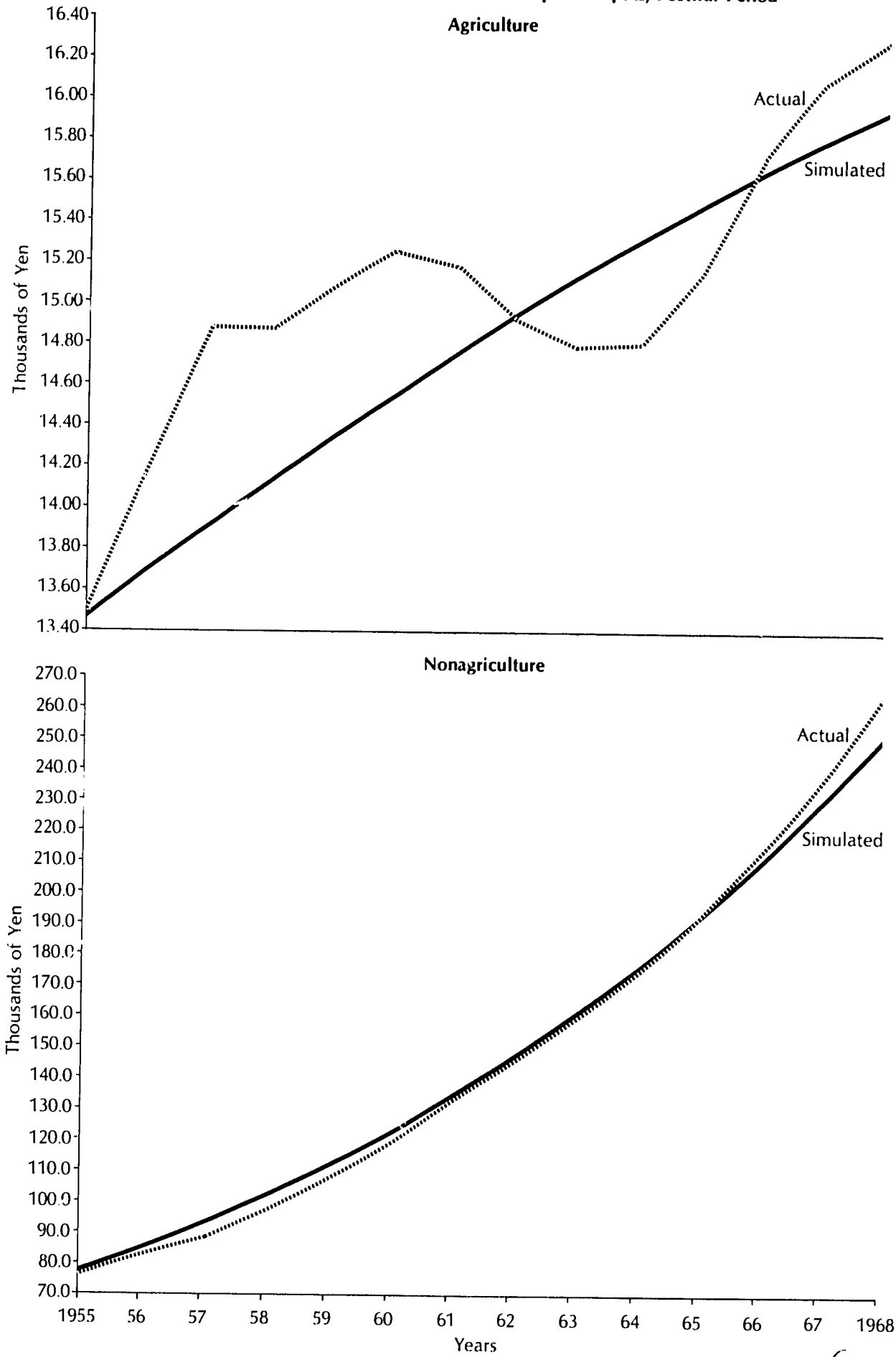


Figure 11. Actual and Simulated Labor Force Levels, Postwar Period

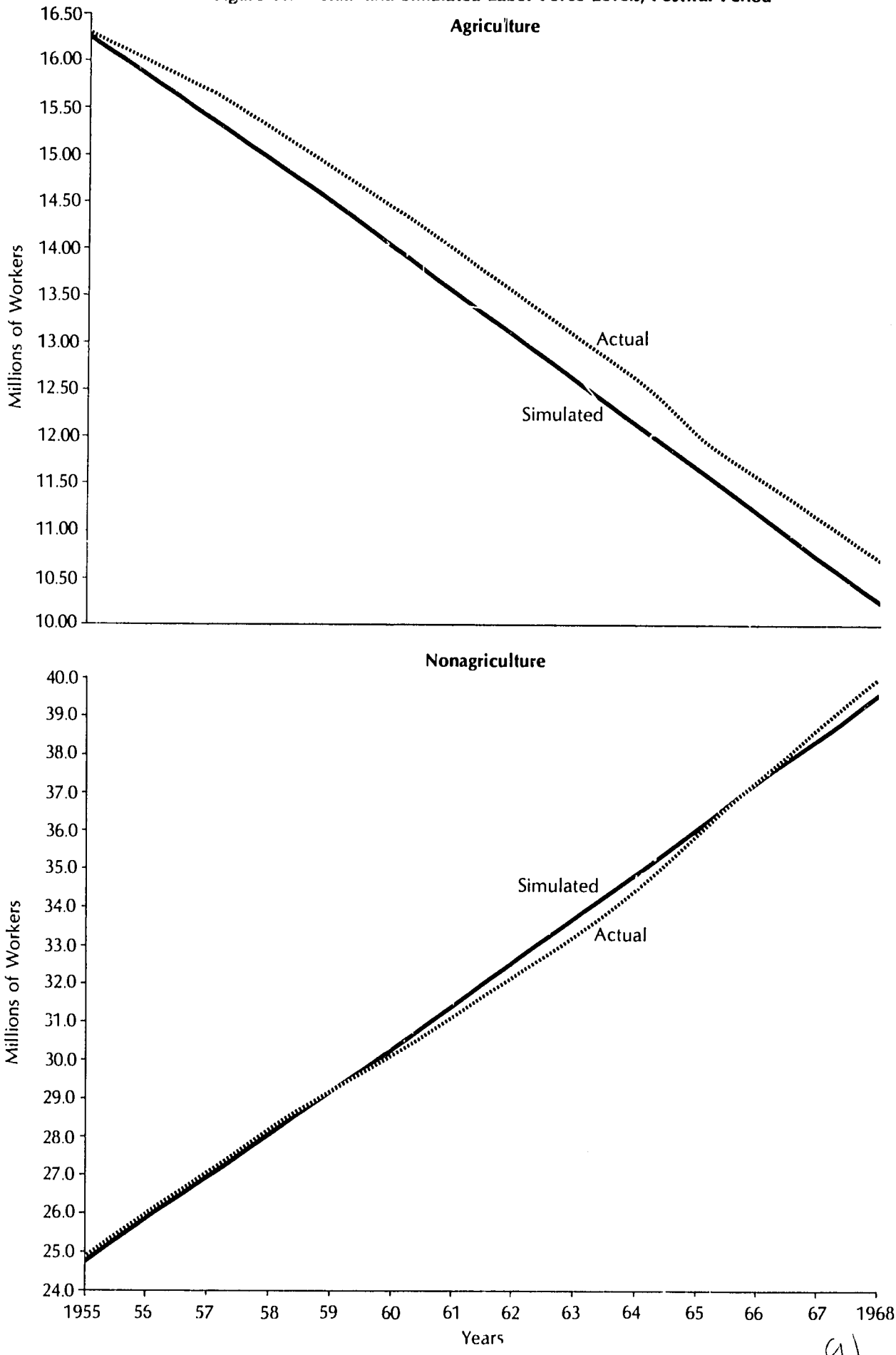
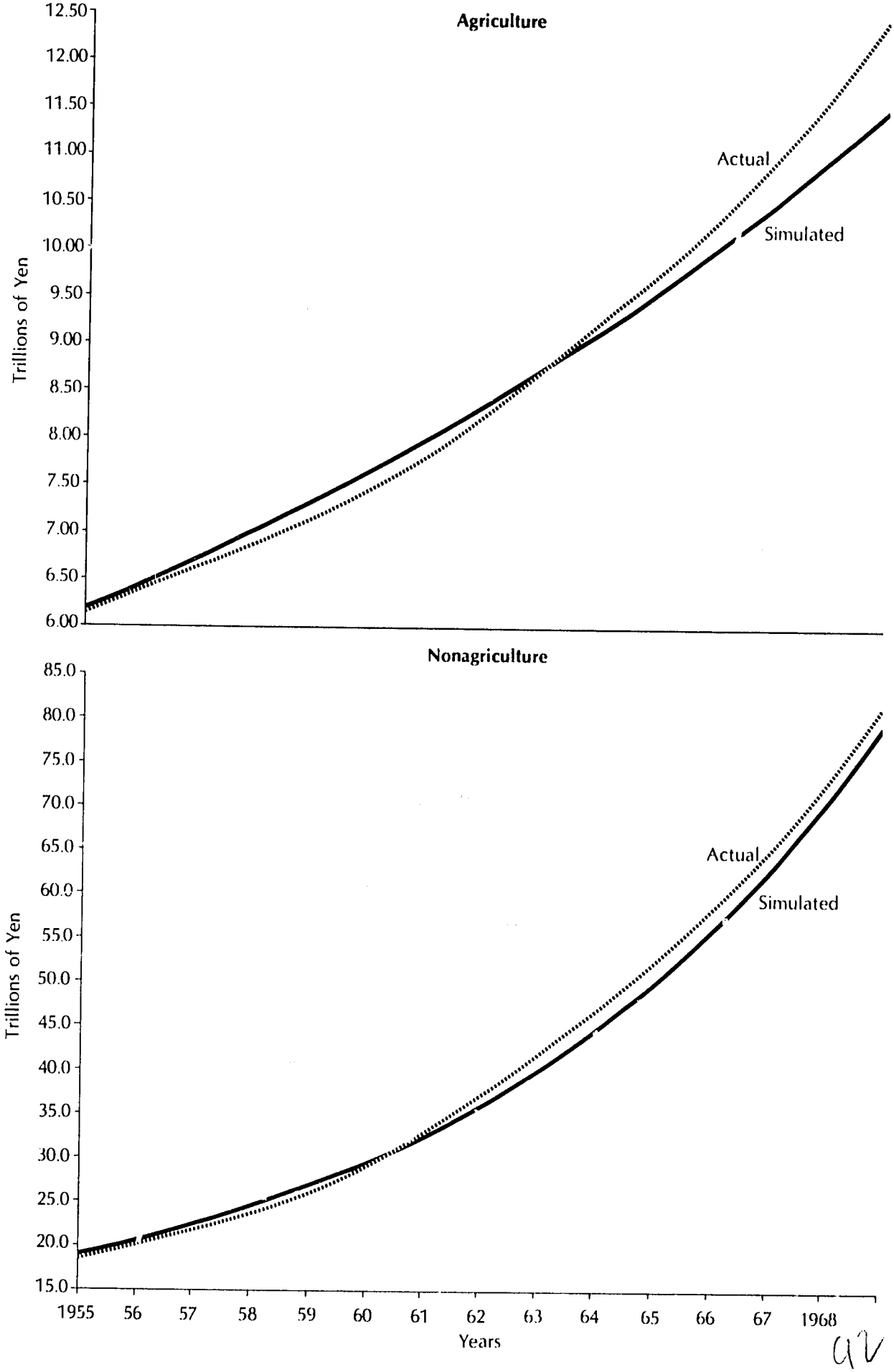


Figure 12. Actual and Simulated Capital, Postwar Periods




92

Figure 13. Actual and Simulated Terms of Trade Between Agricultural and Nonagricultural Sections, Postwar Period

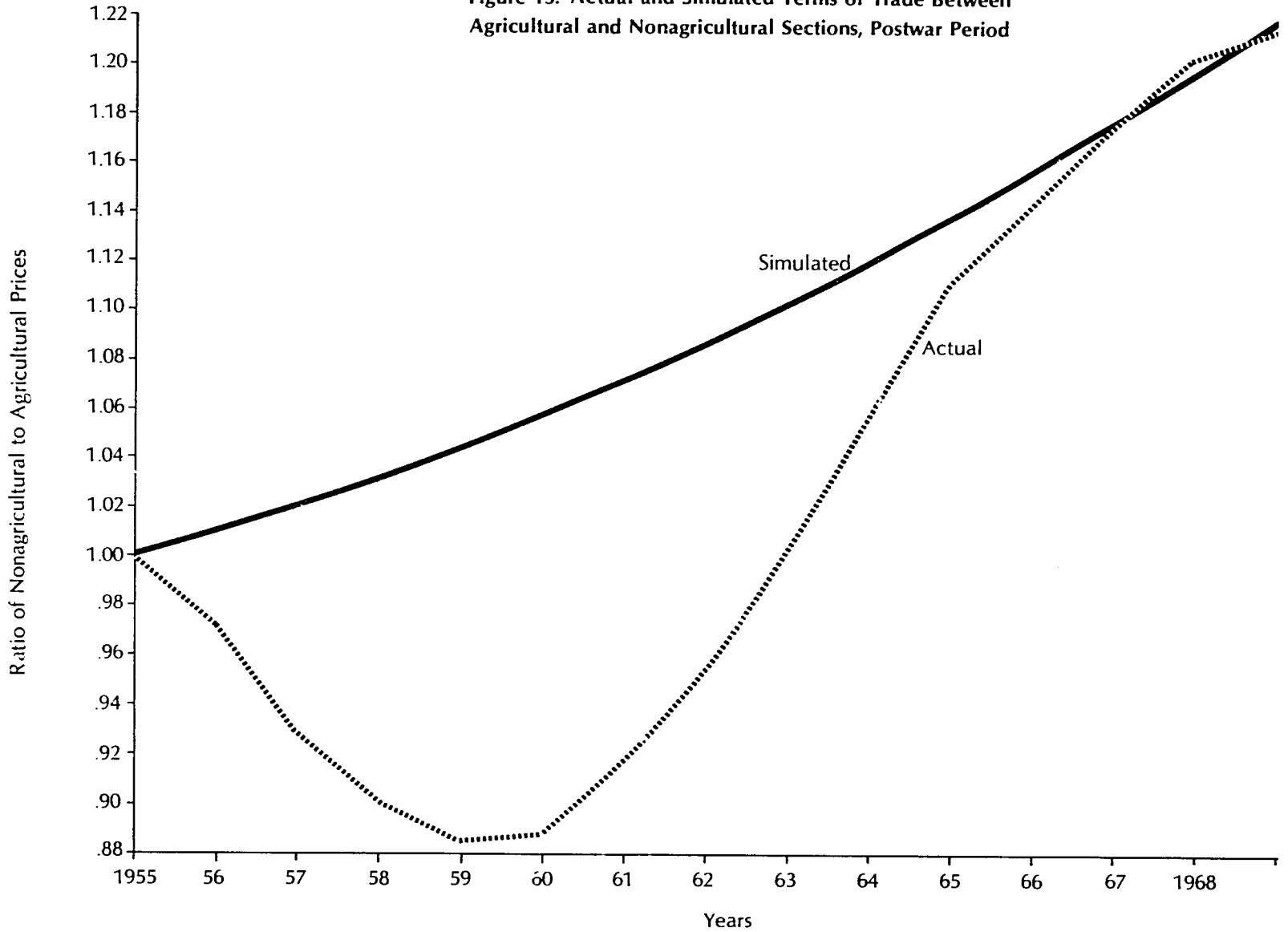
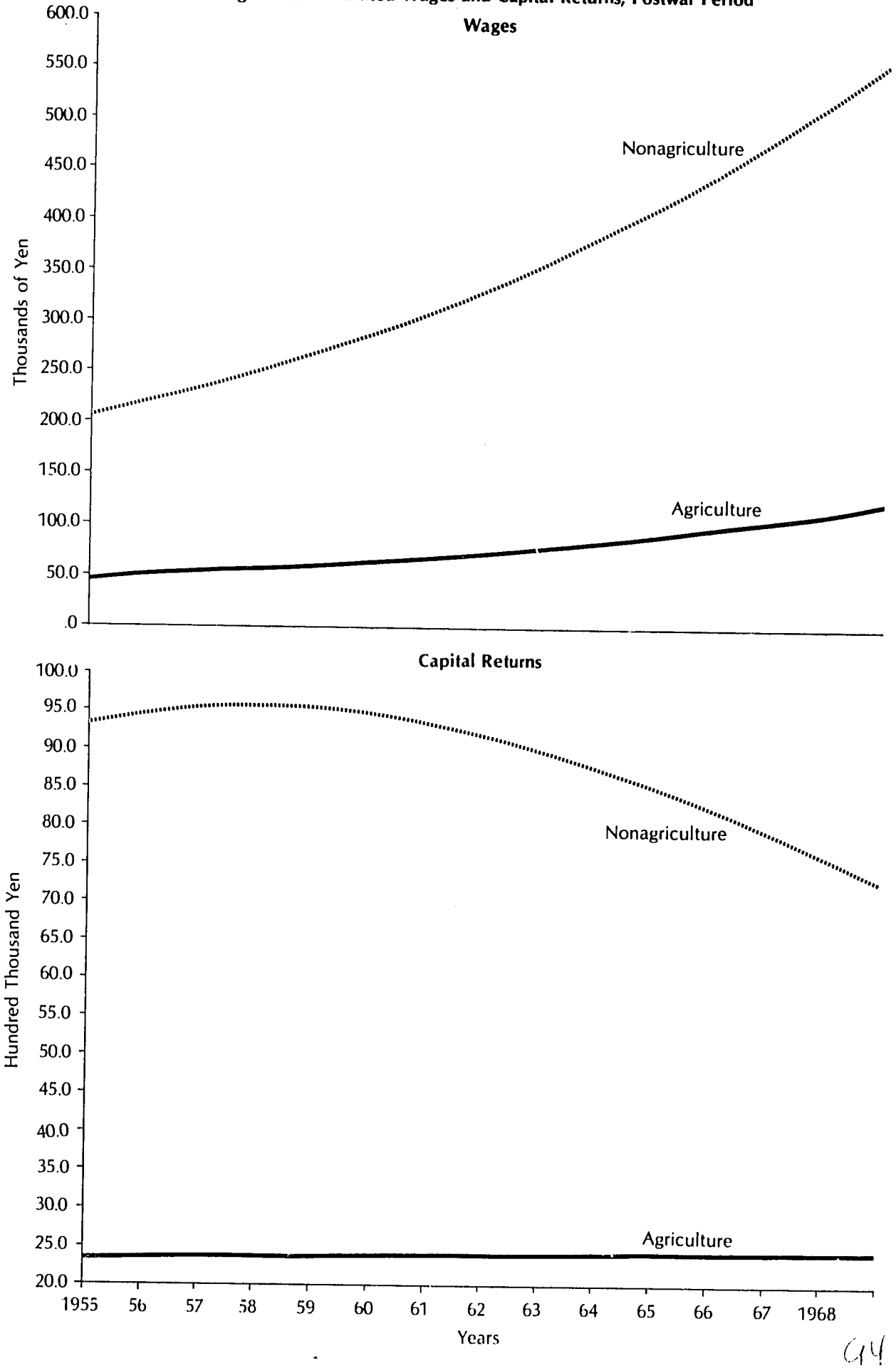


**Figure 14. Simulated Wages and Capital Returns, Postwar Period**



and in some cases also capital to the N sector. This mutual relationship is sometimes considered the contribution of agriculture to the N sector.[92] This is a somewhat limited point of view, because basically the N sector contributes to economic growth by accepting and employing the surplus labor of the A sector. The difference is largely semantic; what really matters is the flow of resources and products.

In order to quantify the importance of resource flows in development, we conducted the following experiment: we simulated the growth of the Japanese economy under the assumption that there were no intersectoral resources flows. We isolated the individual effects of labor and savings flow growth paths by simulations in which there was (1) no flow of either factor, (2) no labor migration but flow of savings, and (3) labor migration but no savings flow. The restriction of no savings flow requires adjusting initial investment figures in order to maintain the national accounting identities. With this modification, each sector's savings are invested completely within that sector.

The prewar analysis was carried under the assumptions of Run 1. The period is analyzed as a whole rather than subdivided into two separate periods, and the values of the parameters are those of Run 1 except that the flow of resources is restricted as specified. Representing the prewar years, Table 16 reports for 1937. For purposes of comparison, the table also reports the results of Run 1 and actual values for 1937 taken from Table 14. Results for each alternative formulation are also expressed as a percentage of the actual values. Table 17, which reports for the postwar year 1968, is similarly constructed.

In terms of the effect on per capita output it is quite clear that labor migration was by far more important than the flow of savings. For instance, the simulated values for 1937 indicate that if the Japanese economy had experienced only labor migration but no savings flow, per capita production in A and N would have been 105 and 99 percent of their respective actual values—a minor change indeed. On the other hand, savings flow without labor migration would have resulted in per capita production 123 and 75 percent of the actual values in the A and the N sectors, respectively,

The basic run (Run 1) did not perform well on simulating the actual price ratio; for 1937, the difference is 17 percent. The run with no savings flow is not far from Run 1, and its price result does not differ much. On the other hand, the no-migration run brings the price ratio down to 93 percent of the actual, and restricting the flow of both factors brings the price ratio down to 89 percent of the actual.

Turning to the factor allocation, the no-migration restriction results in a 39 percent increase in the agricultural labor force and a decline of similar order of magnitude in the N labor force. This restriction also results in greater capital accumulation in agriculture; $K_1$ is 15 percent more than the actual, and $K_2$ is only 84 percent of the actual.

The restriction on savings flow is not translated quickly and strongly into the labor market; labor allocation is unaffected. On the other hand, restricting savings flow increases the A capital stock by about 20 percent and decreases the N capital stock by 9 percent. The reason that the savings restriction affects output less than the restric-

[92] Cf. Ohkawa, *Differential Structure*, pp. 169-72.

## Table 16—Restrictions on resource flow, 1937

| Variable[a] | Actual | Run 1 | | No Migration/ No Savings Flow | | No Migration | | No Savings Flow | |
|---|---|---|---|---|---|---|---|---|---|
| | | S | P | S | P | S | P | S | P |
| $y_1$ | 25.2 | 25.7 | 1.02 | 32.0 | 1.27 | 31.0 | 1.23 | 26.5 | 1.05 |
| $y_2$ | 105.6 | 108.4 | 1.03 | 75.7 | 0.72 | 78.8 | 0.75 | 104.3 | 0.99 |
| $L_1$ | 14.5 | 14.4 | 0.99 | 20.1 | 1.39 | 20.1 | 1.39 | 14.5 | 1.00 |
| $L_2$ | 17.2 | 17.1 | 0.99 | 11.4 | 0.66 | 11.4 | 0.66 | 17.1 | 0.99 |
| $K_1$ | 5.7 | 5.8 | 1.00 | 8.0 | 1.39 | 6.6 | 1.15 | 7.4 | 1.28 |
| $K_2$ | 24.8 | 24.8 | 1.00 | 18.7 | 0.75 | 20.9 | 0.84 | 22.4 | 0.91 |
| $p$ | 0.91 | 1.07 | 1.17 | 0.81 | 0.89 | 0.85 | 0.93 | 1.02 | 1.11 |
| $w_1$ | | 72.0 | | 50.3 | | 51.4 | | 70.34 | |
| $w_2$ | | 283.1 | | 298.1 | | 313.6 | | 270.5 | |
| $r_1$ | | 3.8 | | 2.7 | | 3.4 | | 3.0 | |
| $r_2$ | | 10.8 | | 9.9 | | 9.0 | | 11.7 | |
| R | | 99.7 | | 91.6 | | 93.6 | | 97.6 | |
| $k_1$ | 4.0 | 4.0 | 1.01 | 4.0 | 1.00 | 3.1 | 0.77 | 5.1 | 1.29 |
| $k_2$ | 14.4 | 14.4 | 1.00 | 16.3 | 1.14 | 18.2 | 1.27 | 13.1 | 0.91 |
| $\ell$ | 0.458 | 0.457 | 1.00 | 0.638 | 1.39 | 0.638 | 1.39 | 0.459 | 1.00 |
| $\rho$ | 0.188 | 0.199 | 1.06 | 0.258 | 1.37 | 0.201 | 1.07 | 0.250 | 1.33 |
| $\pi$ | 0.193 | 0.202 | 1.05 | 0.256 | 1.33 | 0.251 | 1.30 | 0.205 | 1.06 |
| $w_1/p$ | | 67.6 | | 61.8 | | 60.3 | | 69.2 | |
| $r_1/p$ | | 3.6 | | 3.3 | | 4.0 | | 3.0 | |
| $pk_1$ | | 4.2 | | 3.[illegible] | | 2.6 | | 5.2 | |
| $pk_1/k_2$ | | 0.294 | | 0.198 | | 0.143 | | 0.394 | |
| $m$ | 1.2 | 1.3 | | 0.0 | | 0.0 | | 1.3 | |

Note: S = simulated values; P = simulated/actual; empty cells indicate that data were not available.
[a]See Table 14 for units.

## Table 17—Restrictions on resource flow, 1968

| Variable[a] | Actual | Base Run | | No Migration/ No Savings Flow | | No Migration | | No Savings Flow | |
|---|---|---|---|---|---|---|---|---|---|
| | | S | P | S | P | S | P | S | P |
| $y_1$ | 16.3 | 16.0 | 0.98 | 24.3 | 1.49 | 24.0 | 1.47 | 16.1 | 0.99 |
| $y_2$ | 263.3 | 249.5 | 0.95 | 199.3 | 0.76 | 200.0 | 0.76 | 248.6 | 0.94 |
| $L_1$ | 10.7 | 10.3 | 0.96 | 19.7 | 1.84 | 19.7 | 1.84 | 10.3 | 0.96 |
| $L_2$ | 39.9 | 39.6 | 0.99 | 30.1 | 0.75 | 30.1 | 0.75 | 39.6 | 0.96 |
| $K_1$ | 11.6 | 11.0 | 0.95 | 13.5 | 1.16 | 12.3 | 1.05 | 12.0 | 1.03 |
| $K_2$ | 72.2 | 70.5 | 0.98 | 62.5 | 0.87 | 63.6 | 0.88 | 69.3 | 0.96 |
| P | 1.20 | 1.197 | 1.00 | 0.663 | 0.57 | 0.696 | 0.58 | 1.173 | 0.98 |
| $w_1$ | | 114.1 | | 56.3 | | 56.7 | | 113.0 | |
| $w_2$ | | 515.3 | | 538.4 | | 541.0 | | 513.0 | |
| $r_1$ | | 2.4 | | 1.7 | | 1.8 | | 2.2 | |
| $r_2$ | | 7.6 | | 6.6 | | 6.5 | | 7.8 | |
| R | | 79.8 | | 66.1 | | 66.5 | | 79.0 | |
| $k_1$ | 10.9 | 10.7 | 0.99 | 6.8 | 0.63 | 6.2 | 0.57 | 11.7 | 1.07 |
| $k_2$ | 18.1 | 17.8 | 0.98 | 20.8 | 1.15 | 21.1 | 1.17 | 17.5 | 0.97 |
| $\ell$ | 0.211 | 0.206 | 0.98 | 0.396 | 1.88 | 0.396 | 1.88 | 0.206 | 0.98 |
| $\rho$ | 0.139 | 0.157 | 1.13 | 0.128 | 0.92 | 0.118 | 0.85 | 0.168 | 1.21 |
| $\pi$ | 0.058 | 0.071 | 1.22 | 0.077 | 1.33 | 0.077 | 1.33 | 0.071 | 1.22 |
| $w_1/p$ | | 95.4 | | 82.4 | | 81.5 | | 96.3 | |
| $r_1/p$ | | 2.0 | | 2.4 | | 2.6 | | 1.9 | |
| $pk_1$ | | 12.8 | | 4.7 | | 4.3 | | 13.7 | |
| $pk_1/k_2$ | | 0.722 | | 0.224 | | 0.204 | | 0.781 | |
| $m$ | 5.5 | 6.0 | | 0.0 | | 0.0 | | 6.0 | |

Note: S = simulated values; P = simulated/actual; empty cells indicate that data were not available.
[a]See Table 15 for units.

tion on migration is in part related to the fact that labor allocation is not greatly affected by restricting savings flow and in part to the fact that capital-production elasticities are smaller than labor-production elasticities. This is basically related to the old question of the direct contribution of investment to growth. The no-migration, no-flow alternative combines the two individual effects in an obvious way.

The postwar results are similar in nature, but they are basically of a larger magnitude than the prewar results. This primarily reflects the importance of labor migration during the later period. Table 17 shows that the absence of migration up to 1968 would have resulted in 47 percent larger per capita agricultural production in 1968 than in 1955. The discrepancy was accumulated during a 13-year period (1955-68); during the 30 years (1907-37) of the prewar period, a 23 percent discrepancy accumulated. The effect on per capita production in the N sector is to reduce it to 76 percent of the actual value, or 80 percent of the base run.

Obviously, such drastic changes in production have corresponding effects on prices. Had there been no labor migration in the postwar period, the price ratio would have gone down to a level of 64 percent of its actual value and to a level of 58 percent of that obtained in the base run.[93] Thus, it would have been disastrous for Japanese agriculture if the high rate of technical change realized in the postwar period had not been associated with high rates of migration. It is the labor migration that made it possible to reduce the agricultural labor force by almost one-half during a 13-year period. This change is reflected in the deepening of capital-labor ratio at a rate faster than that realized in the N sector.

## The Role of Technical Change and Accumulation

There was a great deal of difference in the saving rates and in the rates of technical change between the prewar and the postwar periods. From a historical perspective, the question really is whether an economy's more crucial parameters must change gradually in order to achieve high growth rates or whether it is at all possible to make some shortcuts in moving into the set of high-growth parameters. The problem, then, is how to induce high rates of technical change and possibly high rates of accumulation. Such inducements are not priceless, so the question is whether the benefits of such inducements are worth the cost. This problem is approached in the literature from different points of view, and there is a whole set of studies that evaluate the consequences of research and development.

Another approach to evaluating the consequences of speeding up technical change and savings is simply to trace the growth path of the economy. We have performed this evaluation under the following assumptions. First, we asked what would have been the course of the prewar development of Japan if the prewar rates of technical change were replaced by the postwar rates of about 4 percent per year for agriculture and more than 5 percent for the rest of the economy. We followed a similar procedure

[93]In fact, the effect is likely to be somewhat weaker. The production function used in the simulation does not include raw materials such as fertilizers, seeds, etc. The effect of changes in these inputs over time is embedded in the residual technical change. As such, it is implicitly assumed that the level of their use is independent of price. Such an assumption may yield a reasonable approximation for small-to-moderate price variations. The price deviations realized in the present exercise are larger by far.

with respect to saving rates. The results are reported in Table 18. Conversely, we examined the consequences of applying prewar technical change rates and saving rates to the postwar economy, and these results appear in Table 19.

Applying the postwar rates of technical change to the prewar period would have resulted in a per capita production 2.44 and 5.45 times larger, respectively, than the actual values observed in the A and N sectors. Adopting the postwar saving rates would have resulted in greater production by 1.12 in the A sector and 1.24 in the N sector. Thus, under the present assumptions, it is technical change that contributed mostly to growth in the postwar period; or said differently, it is largely the lack of technical change that prevented prewar Japan from realizing the postwar rate of growth.

The results in Table 19 reinforce this conclusion. If the prewar rates of technical change had prevailed in the postwar period, 1968 per capita outputs would have reached only 68 and 51 percent of their respective actual values in the A and N sectors. On the other hand, if the prewar saving rates had prevailed postwar, the outputs would have been 93 percent of actual in the A sector and 85 percent in the N sector.

**Table 18—Prewar economy with postwar technical change and saving rates, simulation results, 1937**

| Variable[a] | Actual | Base Run | | Postwar Technical Change | | Postwar Saving rates | |
|---|---|---|---|---|---|---|---|
| | | S | P | S | P | S | P |
| $y_1$ | 25.2 | 25.7 | 1.02 | 61.4 | 2.44 | 28.2 | 1.12 |
| $y_2$ | 105.6 | 108.4 | 1.03 | 575.0 | 5.45 | 130.9 | 1.24 |
| $L_1$ | 14.5 | 14.4 | 0.99 | 13.5 | 0.93 | 14.1 | 0.97 |
| $L_2$ | 17.2 | 17.1 | 0.99 | 18.1 | 1.05 | 17.4 | 1.01 |
| $K_1$ | 5.7 | 5.8 | 1.00 | 8.8 | 1.53 | 13.7 | 2.39 |
| $K_2$ | 24.8 | 24.8 | 1.00 | 71.1 | 2.87 | 40.3 | 1.63 |
| $p$ | 0.91 | 1.07 | 1.17 | 0.76 | 0.83 | 1.00 | 1.10 |
| $w_1$ | | 72.0 | | 129.7 | | 74.5 | |
| $w_2$ | | 283.0 | | 1562. | | 351.1 | |
| $r_1$ | | 3.8 | | 4.6 | | 1.8 | |
| $r_2$ | | 10.8 | | 16.9 | | 7.1 | |
| R | | 99.7 | | 170.7 | | 101.3 | |
| $k_1$ | 4.0 | 4.0 | 1.01 | 6.5 | 1.65 | 9.7 | 2.46 |
| $k_2$ | 14.4 | 14.5 | 1.00 | 33.9 | 2.36 | 23.1 | 1.61 |
| $\ell$ | 0.458 | 0.457 | 1.00 | 0.427 | 0.93 | 0.448 | 0.98 |
| $\rho$ | 0.188 | 0.199 | 1.06 | 0.086 | 0.46 | 0.254 | 1.35 |
| $\pi$ | 0.193 | 0.202 | 1.05 | 0.075 | 0.39 | 0.178 | 0.92 |
| $w_1/p$ | | 67.6 | | 170.3 | | 74.4 | |
| $r_1/p$ | | 3.6 | | 6.0 | | 1.8 | |
| $pk_1$ | | 4.2 | | 5.0 | | 9.7 | |
| $pk_1/k_2$ | | 0.294 | | 0.126 | | 0.419 | |
| $m$ | 1.2 | 1.3 | | 1.9 | | 1.4 | |

Note: S = simulated values; P = simulated/actual; empty cells indicate that data are not available.
[a]See Table 14 for units.

**Table 19—Postwar economy with prewar technical change and saving rates, simulation results, 1968**

| Variable[a] | Actual | Base Run | | Prewar Technical Change | | Prewar Saving Rates | |
|---|---|---|---|---|---|---|---|
| | | S | P | S | P | S | P |
| $y_1$ | 16.3 | 16.0 | 0.98 | 11.1 | 0.68 | 15.1 | 0.93 |
| $y_2$ | 263.3 | 249.5 | 0.95 | 135.6 | 0.51 | 223.2 | 0.85 |
| $L_1$ | 10.7 | 10.3 | 0.96 | 10.8 | 1.01 | 10.4 | 0.97 |
| $L_2$ | 39.9 | 39.6 | 0.99 | 39.1 | 0.98 | 39.5 | 0.99 |
| $K_1$ | 11.6 | 11.0 | 0.95 | 10.0 | 0.86 | 7.0 | 0.60 |
| $K_2$ | 72.2 | 70.5 | 0.98 | 54.9 | 0.76 | 43.1 | 0.60 |
| $p$ | 1.20 | 1.20 | 1.00 | 1.48 | 1.23 | 1.20 | 1.00 |
| $w_1$ | | 114.1 | | 95.8 | | 108.8 | |
| $w_2$ | | 515.3 | | 276.7 | | 448.7 | |
| $r_1$ | | 2.4 | | 2.2 | | 3.4 | |
| $r_2$ | | 7.6 | | 5.5 | | 12.8 | |
| R | | 79.8 | | 69.1 | | 76.6 | |
| $k_1$ | 11.1 | 10.7 | 0.99 | 9.3 | 0.86 | 6.8 | 0.62 |
| $k_2$ | 18.1 | 17.8 | 0.98 | 14.0 | 0.78 | 10.9 | 0.60 |
| $\ell$ | 0.211 | 0.206 | 0.98 | 0.216 | 1.02 | 0.208 | 0.99 |
| $\rho$ | 0.139 | 0.157 | 1.13 | 0.213 | 1.53 | 0.164 | 1.18 |
| $\pi$ | 0.058 | 0.071 | 1.22 | 0.108 | 1.86 | 0.075 | 1.29 |
| $w_1/p$ | | 95.4 | | 64.7 | | 90.6 | |
| $r_1/p$ | | 2.0 | | 1.5 | | 2.8 | |
| $pk_1$ | | 12.8 | | 13.8 | | 8.1 | |
| $pk_1/k_2$ | | 0.722 | | 0.985 | | 0.745 | |
| $m$ | 5.5 | 6.0 | | 5.1 | | 5.8 | |

Note: S = simulated values; P = simulated/actual; empty cells indicate that data are not available.
[a]See Table 18 for units.

The values of the other endogenous variables under these alternatives appear in Tables 18 and 19. The behavior of the rates of labor migration may be of particular interest. Thus, the actual 1938 value for labor migration is 1.2 percent a year and the simulated value of the base run is 1.3 percent; the value obtained by applying the postwar rate of technical change is 1.9 percent, and that obtained using the postwar saving rate is 1.4 percent. It is clear that part of the faster growth of the N sector, shown in Table 18, is due to greater labor migration associated with the technical change and the saving rates alternatives. The opposite is seen in Table 19; here, applying the prewar rate of technical change reduced the 1968 simulated labor migration from 6 percent to 5.1 percent.

The implications of this exercise are clear and extremely important. The contribution of investment to growth is of lesser importance than the contributions of labor and technical change. However, the real question is the extent to which technical change is independent of investment. This is basically the question raised by Solow in his embodiment hypothesis.[94] A great deal of work has taken place since this question was raised, but the answer is still not clear.

[94]R. M. Solow, "Technical Progress, Capital Formation and Economic Growth," *American Economic Review* (1969): 76-86.

In the present analysis, this question is of immediate interest. The rates of capital accumulation and the rates of technical change are positively correlated, so both are lower in the prewar period and higher in the postwar period. The exercise was carried out under the assumption that the two are independent, but, if this is not the case, then investment would actually have been more productive than it appears here. But without a basis for quantifying the productivity of investment, it remains for future research to cast more light on this issue.

## Concluding Remarks

We have demonstrated that the model presented in Chapter 5 is appropriate for use with Japanese data. The fit, in general, was good for the physical variables which were not subject to wide annual fluctuations. However, with a few exceptions, the simulation was derived from a single set of parameters for each of the two periods that were investigated.

Except for the equations estimated in this study, the values of the parameters in question were generally taken from the literature. No attempt was made to optimize the fit by searching for proper parameters; the fit could be further improved by such a procedure. It is of interest to examine the technique by which better parameters might be estimated in future research. In so doing, attention should also be given to allowing the parameters to vary over time. However, introducing parameter variations over time is not just a question of technique, for there must be some underlying structure which guides the researcher in the selection of such values. As indicated at the end of Chapter 5, in the background of all this lie the more profound problems of identification.

Although the results of the present study may in the future be refined by a proper set of parameters and the corresponding simulated growth path, some conclusions will survive. It is widely believed that growth originates in accumulating resources and in improving their utilization. Because we are interested in per capita growth, accumulation here refers to capital accumulation. The high saving rates observed in Japan, particularly in the postwar period, resulted in rapid accumulation. However, the direct quantitative effect of this accumulation on growth is not conspicuously large. Those who believe that this effect is pronounced may find it difficult to demonstrate this belief convincingly to a nonbeliever.

Improving the utilization of resources has two aspects: first, improvement in intersectoral resource allocation, and second, all other improvements, which come under the heading of technical change. The first refers in this study to the flow of labor and savings from origins of low returns to destinations of high returns. This is well recognized as an important source of growth in Japan.

Our study leads us to suggest that the main quantitative effect came from labor migration and, in contrast to prevailing opinion, the flow of savings was only of secondary importance. This statement should be somewhat qualified, however. Our study starts with 1907, when the rate of savings flow was governed primarily by the land tax; however, this flow had been much larger in the preceding period, starting with the Meiji Restoration. The conclusion also is dependent on the limited direct

effect that capital accumulation was found to have on production. If indeed the effect of investment on production is limited, then our conclusion might also be applicable to the first stage of Japanese economic growth.

There is one way to get some insight into the process without settling the question of how much effect investment has on growth; this is to compute the proportion of nonagricultural investment that was financed by flow of savings from agriculture. In a recent paper, Teranishi claims that this proportion was relatively small and expresses doubts about the importance of intersectoral capital flows to Japanese economic growth.[95]

Regardless of the verdict on the role of intersectoral savings flow, one can still conclude that social organizations that are conducive to the reallocation of resources in line with their relative returns contribute to economic growth. Other things being equal, the larger the intersectoral differences in returns, the larger the potential for growth resulting from resource reallocation.

The second aspect of improving the utilization of resources is the Pandora's box of technical change. The importance of this source is well recognized. Our framework provides some orders of magnitude, but other than that it suggests only two observations on the subject. First, the quantitative effect of technical change is unlikely to be independent of capital accumulation. Thus, any lessons that are to be drawn from the Japanese experience depend on clarifying this point. Second, Hayami and his associates convey the message that some of the Japanese experience, in contrast to that of land-intensive countries, consists of developing land-augmenting technical change. That may indeed be so but it does not come out in the analysis as clearly as it is claimed.

Questions that can be asked in this context are: What exactly is the measure used? To what extent was the technical change augmenting? How did the Japanese experience differ from that of some of the other countries that also realized growth? No matter what the answers may be, there is no question that technical change is an extremely effective engine of growth. This has also been demonstrated by the case of Japan.

---

[95]J. Teranishi, "The Pattern and Role of Flow of Funds Between Agriculture and Nonagriculture in Japanese Economic Development," mimeographed, n.p., n.d.

# APPENDIX A

## THE DATA FOR CHAPTER 2 AND THEIR SOURCES

The data on economically active population, GDP (except for the OECD Countries), and education were obtained from the International Bank for Reconstruction and Development (IBRD), *World Tables 1975*, parts I and IV. The sample includes virtually all the countries for which the data were complete; Peru and Bolivia were not included because we suspected some serious errors in the data. The result was a sample of 70 countries, which are listed below:

Rwanda, Lebanon, Pakistan, Bangladesh, Dahomey, Ethiopia, Indonesia, Niger, Upper Volta, Zaire, India, Madagascar, Nigeria, Sierra Leone, Sudan, Thailand, Colombia, Congo, Dominican Republic, Ecuador, Egypt, Arab Republic of, El Salvador, Ghana, Guatemala, Guyana, Honduras, Ivory Coast, Jordan, Korea, Republic of, Liberia, Morocco, Paraguay, Philippines, Tunisia, Barbados, Brazil, Chile, Costa Rica, Cyprus, Gabon, Iran, Jamaica, Malaysia, Mexico, Nicaragua, Panama, Uruguay, Venezuela, Argentina, Australia, Austria, Israel, Sweden, Turkey*, Portugal*, Belgium*, Canada*, Denmark*, Finland*, France*, Germany, Federal Republic of*, Greece*, Ireland*, Italy*, Japan*, Netherlands*, Norway*, Spain*, U.K.*, U.S.A.*

For the OECD countries, data were also available for 1950, and this is denoted by a * following the name of the country. *Economically active population:* The original source on which the World Tables are based is the International Labor Organization (ILO), *Yearbook of Labor Statistics*, various issues. The 1950 data were obtained from the ILO *Labor Force Projections 1965-1985*.

The series include both employed and unemployed persons, as well as unpaid family labor. However, the latter series is constructed differently in different countries and years, particularly with respect to the coverage of women and teenagers. Because women are likely to constitute a larger proportion of the labor force in agriculture than in the other sectors, the main effect of the heterogeneity in the data is on the construction of the income differential variable ($\delta$). It is hoped that better data in the future will make it possible to correct for this.

*Migration:* The text explains the computation of the two migration series. It should be recalled that for some countries the data relate to years other than 1950, 1960, or 1970. We normalized the data by calculating the average (simple) annual migration between the two end years of the relevant period.

*GDP:* The source for GDP is *World Tables 1975*, except for the OECD countries, for which the data were obtained from various issues of the *National Accounts Yearbook* of the United Nations. It should be noted that the *World Tables* data are based on the

United Nations data, but the data are edited and, if necessary, adjusted by the IBRD. This situation reflects the fact that the United Nations is obliged to use the data as they are submitted by governments. At this stage, it is impossible to assess the adjustments, because the procedures have not yet been published.

The GDP originating in agriculture also includes hunting, forestry, and fishing (so, incidentally, do the labor data). The data for Tunisia are for 1961 and for Sierra Leone are for 1964. This is also the case for the nonagricultural GDP data. Otherwise, the data are for the stated years. Although data are reported in local currencies, we were interested only in the ratios, so there was no need for intercountry comparisons of currencies.

*Age:* Two age variables were attempted in the analysis: (1) Persons in the age group 15-29 years as a proportion of total population in or about 1960, and (2) persons aged 30-39 years as a proportion of total population in or about 1960.

Data for Rwanda, Lebanon, and Pakistan were not available and therefore regressions with age variables were computed without these countries. The source for the total population was *World Tables 1975,* whereas data on age distribution were from various issues of the *Demographic Yearbook* of the United Nations. For most of the countries, the distribution by age was available for the interval of 1958 to 1962.

*Education:* The source is *World Tables 1975,* which are based on various issues of the UNESCO *Statistical Yearbook*. In addition to the variable discussed in the text, we also attempted another variable: enrollment of all ages in primary schools as a percentage of primary school-age population. This variable was not statistically different from zero at acceptable levels.

The summary measures of these data are given in Table 20.

## Table 20—Summary measures of the data

| Variable | 70 Countries | | | OECD Countries | | |
|---|---|---|---|---|---|---|
| | Mean | S.D.[a] | Range | Mean | S.D.[a] | Range |
| Migration ($M_1$) as percentage of agricultural labor force: | 2.11 | 1.45 | 0.17 - 6.72 | 3.27 | 1.25 | 0.63 - 5.45 |
| $M_2$ | 2.49 | 1.46 | 0.47 - 7.23 | 3.35 | 1.32 | 0.80 - 5.58 |
| Income differential, $\delta$ | 4.01 | 3.61 | 0.94 -22.37 | 2.28 | 1.13 | 0.89 - 6.94 |
| Ratio of nonagricultural to agricultural labor, $r$ | 2.44 | 3.90 | 0.03 -25.32 | 4.70 | 5.44 | 0.15 -25.32 |
| Education[b] | 0.254 | 0.234 | 0.01 - 0.86 | 0.518 | 0.192 | 0.15 - 0.86 |
| Average annual rate of labor force growth, $1 + n$ | 1.022 | 0.022 | 0.988 - 1.147 | 1.007 | 0.0099 | .987- 1.034 |
| Age, 15-29[b] | 0.238 | 0.028 | 0.17 - 0.32 | 0.219 | 0.0251 | 0.19 - 0.28 |
| Age, 30-39[b] | 0.129 | 0.016 | 0.09 - 0.18 | 0.136 | 0.0150 | 0.09 - 0.15 |

[a]S.D. = standard deviation.
[b]The education and age figures for the OECD countries relate to 1960.

# APPENDIX B

## BACKGROUND OF CHAPTER 3 ANALYSIS

### Derivation of the Data Series

The definition and the sources of the data used to compute the variables needed for the analysis of Japanese migration are described below. In general, we have used only published data that have been analyzed by other authors also.

The migration variable was obtained from the labor force data under the assumption that natural rates of growth of the labor force were equal in the farm and nonfarm sectors. Minami[96] has published two series on migration, to which Ohkawa and Rosovsky[97] refer as ". . . the best available source." Minami also published a series on farm population.[98] The Minami series on labor force migration is reported only in terms of five-year averages, and the population migration series is reported only for 1920 to 1962. The series that we constructed from the labor force data reported primarily by Ohkawa and Rosovsky covers the period 1905 to 1972. Table 21 summarizes these series as well as related variables.

It appears that our migration series fluctuates much more than that of Minami. However, the cumulative migration is not so different. For instance, averaging the prewar figures, we obtain average annual migration of 149,000 per year for the Minami series and 167,000 for ours;[99] for the corresponding postwar years, the figures are 668,000 and 656,000, respectively. Thus, the main difference is in the fluctuations in migration and not in overall magnitudes.

There is some disagreement between the Minami population and the Minami labor migration data. His average annual population migration for 1921 to 1940 is 362,000, and his average annual labor force migration for the same period is 149,000. This suggests a population migration of 2.44 persons for every worker. If this ratio is applied to the postwar figure, the population migration should have been in the order of magnitude of 1.5 million per year, which is much larger than the figures reported. This discrepancy prevented us from exploiting this series.[100]

Table 22 reports migration ($m$) as a percentage of the agricultural labor force.

---

[96]"The Supply of Farm Labor," p. 85.

[97]*Japanese Economic Growth*, p. 125.

[98]"Population Migration," p. 186.

[99]That level of migration kept the agricultural labor force approximately constant during the prewar period.

[100]Minami is aware of this discrepancy and states: "The reason for overestimation of net outflow of agricultural laborers for the postwar period comes from my assumption that the natural rate of increase of labor force is the same for all sectors. Perhaps in the postwar period, it should be much lower for agriculture than for other sectors" (p. 284). It is clear that absence of actual evidence makes it difficult to settle this question.

## Table 21—Migration and related variables, five-year averages, 1906-70

| Period | Labor Force (Minami) | | Derived Migration | | Farm Population (Minami) | | Income Difference (Productivity Ratio) ($\delta$) | Wage Ratio ($\delta_w$) | Labor Force Ratio ($r$) | Growth Rate of GNE ($g_y + 1$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Thousands of Persons | Percent of Agricultural Labor Force | Thousands of Persons | Percent of Agricultural Force | Thousands of Persons | Percent of Farm Population | | | | |
| Prewar | | | | | | | | | | |
| 1906-10 | 140 | 0.95 | 85 | 0.53 | | | 3.34 | 1.11 | 0.58 | 1.04 |
| 1911-15 | 137 | 0.94 | 231 | 1.44 | | | 3.26 | 1.01 | 0.63 | 1.02 |
| 1916-20 | 178 | 1.21 | 237 | 1.55 | | | 3.08 | 1.05 | 0.79 | 1.06 |
| 1921-25 | 131 | 0.89 | 184 | 1.24 | 328 | 1.09 | 3.16 | 1.35 | 0.92 | 1.02 |
| 1926-30 | 125 | 0.85 | 47 | 0.33 | 205 | 1.07 | 4.01 | 1.62 | 1.00 | 1.02 |
| 1931-35 | 183 | 1.25 | 213 | 1.44 | 465 | 1.47 | 4.79 | 2.37 | 1.06 | 1.06 |
| 1936-40 | 152 | 1.40 | 172 | 1.19 | 450 | 1.42 | 4.11 | 1.85 | 1.21 | 1.05 |
| Postwar | | | | | | | | | | |
| 1951-55 | 760 | 4.58 | 656 | 3.95 | 752 | 2.04 | 2.78 | 2.25 | 1.33 | 1.11 |
| 1956-60 | 752 | 5.10 | 636 | 4.16 | 736 | 2.08 | 2.99 | 2.28 | 1.85 | 1.10 |
| 1961-65 | 492[a] | 3.78[a] | 676 | 5.19 | | | 3.35 | 1.85 | 2.55 | 1.10 |
| 1966-70 | | | 602 | 5.52 | | | 2.98 | 1.74[b] | 3.75 | 1.12 |

Sources: Minami labor force: R. Minami, "The Supply of Farm Labor and the 'Turning Point' in the Japanese Economy," in *Agriculture and Economic Growth: Japan's Experience*, ed. K. Ohkawa *et al.*, 1969; Minami farm population: R. Minami, "Population Migration Away from Agriculture in Japan," *Economic Development and Culture Change* 15 (1967). All other sources are explained in the third section (data sources and definitions) of this appendix.

[a] 1961-64 average.

[b] 1966-69 average.

## Table 22—Means, coefficients of variation, and correlation coefficients for various variables, prewar and postwar periods

| Variables (in Natural Logarithms) | Mean 1910-40 | Mean 1951-72 | Coefficient of Variation 1910-40 | Coefficient of Variation 1951-72 | Correlation Coefficients 1910-40: $m$[a] | $\delta$ | $\delta w$ | $r$ | $(1+n)$ | $(1+gy)$ | Correlation Coefficients 1951-72: $m$ | $\delta$ | $\delta w$[b] | $r$ | $(1+n)$ | $(1+gy)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Annual data* | | | | | | | | | | | | | | | | |
| Migration as percentage of agricultural labor force, $m$ | 1.155 | 4.740 | 1.281 | 0.397 | 1.000 | | | | | | 1.000 | | | | | |
| Income differential, lagged one year, $\delta_{t-1}$ | 3.712 | 3.661 | 0.207 | 0.087 | 0.135 | 1.000 | | | | | 0.287 | 1.000 | | | | |
| Wage differential, $\delta w$ | | | | | 0.035 | 0.784 | 1.000 | | | | −0.274 | −0.274 | 1.000 | | | |
| Ratio of nonagricultural to agricultural labor, $r$ | 0.925 | 2.576 | 0.213 | 0.430 | −0.064 | 0.494 | 0.795 | 1.000 | | | 0.252 | 0.513 | −0.849 | 1.000 | | |
| Annual rate of labor force growth, $1+n$ | 1.008 | 1.018 | 0.003 | 0.012 | −0.005 | 0.534 | 0.441 | 0.333 | 1.000 | | 0.055 | −0.279 | 0.322 | −0.429 | 1.000 | |
| Annual rate of Gross National Expenditure growth, $g_y+1$[c] | 1.038 | 1.108 | 0.035 | 0.106 | 0.382 | 0.155 | 0.176 | 0.089 | −0.271 | 1.000 | 0.239 | −0.031 | 0.020 | 0.106 | −0.050 | 1.000 |
| *Five-year moving averages* | | | | | | | | | | | | | | | | |
| Migration as percentage of agricultural labor force, $m$ | 1.113 | 4.549 | 0.485 | 0.176 | 1.000 | | | | | | 1.000 | | | | | |
| Income differential, lagged one year, $\delta_{t-1}$ | 3.039 | 2.943 | 0.206 | 0.091 | −0.096 | 1.000 | | | | | 0.670 | 1.000 | | | | |
| Wage differential, $\delta w$ | | | | | −0.097 | 0.884 | 1.000 | | | | −0.312 | 0.179 | 1.000 | | | |
| Ratio of nonagricultural to agricultural labor, $r$ | 0.882 | 2.260 | 0.219 | 0.432 | 0.002 | 0.630 | 0.864 | 1.000 | | | 0.740 | 0.765 | −0.112 | 1.000 | | |
| Annual rate of labor force growth, $1+n$ | 1.008 | 1.019 | 0.002 | 0.006 | −0.056 | 0.886 | 0.828 | 0.718 | 1.000 | | −0.404 | −0.633 | −0.594 | −0.666 | 1.000 | |
| Annual rate of Gross National Expenditure growth, $g_y+1$[c] | 1.038 | 1.107 | 0.019 | 0.021 | 0.464 | 0.334 | 0.230 | 0.158 | 0.113 | 1.000 | 0.205 | 0.193 | 0.088 | 0.136 | 0.098 | 1.000 |

[a]0.025 has been added to annual data to obtain positive values.
[b]Correlations are for 1951-69.
[c]In the postwar period, correlations with w are for 1951-69; all others are for 1951-70.

Migration in the postwar period (5.2 percent) has been almost five times higher than in the prewar period (1.1 percent). The annual observations for these data are plotted in Figure 14.

The income differential is measured here as the ratio of average labor productivities in the two sectors. This is done for conceptual reasons which were explained in Chapter 2. It can now be reinforced by a practical consideration Ohkawa and Rosovsky brought up with respect to the Japanese data.

> Furthermore, the very concept of wages in something as traditional as Japanese farming may appear questionable. Japanese agriculture has only very few independent hired workers and their wages are subject to large seasonable fluctuations. Now wage payments in the form of food and lodging are also relatively important. All this means that these indicators had to be presented with caution. Nonetheless, we used wage differentials because they give the best available historical picture of the changing factor price position of the two sectors.

Thus, in the judgment of these experts, the only available data on historical changes in factor prices is of questionable validity.

Minami compares wages and marginal productivity of labor in agriculture and finds the correlation between the two variables quite close.[101] The marginal productivity of labor was derived from a Cobb-Douglas production function, and therefore the reported correlation coefficient is the same as that between wages and average productivity. We have computed the correlation coefficient between the $\delta_w$ –the wage ratio between the two sectors—and $^*\delta$—the income differential measured by the ratio of marginal productivities. For the prewar period (1911-40), these coefficients are 0.78 and 0.88 for the annual and moving-average data, respectively. For the postwar period (1951-69),[102] however, the corresponding figures are −0.27 and 0.18, indicating a weak relationship between wage and productivity ratios (see Figure 15).

It is striking that the wage ratio fluctuates around unity until the depression period of the thirties. Ohkawa and Rosovsky suggest that the wage differential should allow for cost-of-living differences in the two sectors. When this is done, the income differential narrows down to the point that it cannot be used to explain migration.[103]

Yet, throughout the whole period, there has been some incentive for farm labor to move into the nonagricultural sector, and this migration cannot be explained just in terms of expansion of this sector. The incentive is not reflected in the wage series, but this does not necessarily mean that income does not matter; it simply may mean that the wage series is not an appropriate measure of income.

It is also possible that differences in average per capita income between the two sectors have provided a constant incentive for migration. However, the spread in this variable may not be sufficiently large, so that its role in explaining migration may be difficult to capture; but that, by itself, is not an indication that it has not affected migration.

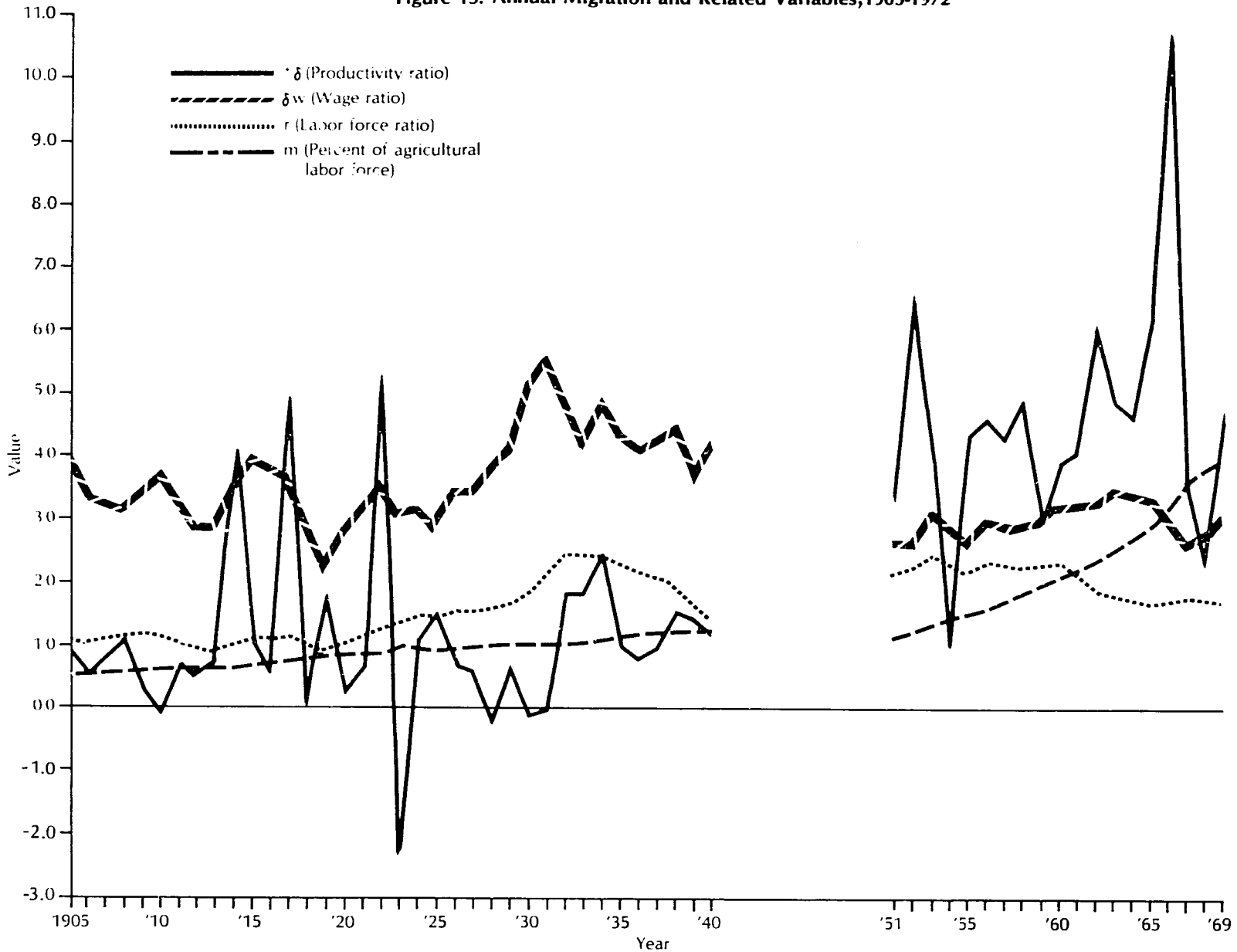
---

[101] "The Supply of Farm labor," p. 286.

[102] The wage series ended in 1969.

[103] Ohkawa and Rosovsky (*Japanese Economic Growth*, p. 126) use a different series for the wage differential. We have chosen the series that has been extended to later years.

Figure 15. Annual Migration and Related Variables,1905-1972



The correlation coefficients of the variables we used in our analysis are given in Table 22. The general pattern for the postwar period is close positive correlation between the five-year moving averages for migration, the income differential, and the labor force ratio; and negative correlation between migration and wages. The correlation coefficients for the annual data are weaker but have the same sign. The correlation coefficients between $g_y$ and migration for the prewar period are 0.382 and 0.464 for the annual data and the five-year moving averages, respectively; the corresponding figures for the postwar period are 0.239 and 0.205. For the prewar period, the correlations between migration and the other variables are somewhat higher for the annual data, but in general, all the prewar coefficients have lower values than those for the postwar period.

## The Minami Analysis

The migration process was studied by Minami in 1967 using a two-equation model.[104] According to his formulation,

$$m_d = f_d\,(w_n, g_n) \qquad \text{(B.1)}$$

$$m_s = f_s\,(w_n, w_a)$$

in equilibrium, $m_s = m_d$,

where

$w_n, w_a$ are nonagricultural and agricultural wages, respectively, each deflated by product prices for that sector,

$g_n$ = rate of growth of the nonagricultural sector, and

$m_d, m_s$ = the demand for and supply of migration expressed as percentages of the agricultural labor force.

This formulation has some deficiencies that cast doubts on its value. The demand equation is the demand for labor in the nonagricultural sector, not the excess demand; that is, some of this demand will be satisfied without migration, by the natural growth of the labor force in that sector. Therefore, the condition that the total labor demand of the nonagricultural sector must equal the supply available from the agricultural sector is not a correct equilibrium condition.

Furthermore, it appears that $m$ is both the rate of migration supplied and that demanded, expressed as a proportion of the agricultural labor force. Such an expression for migration is justified for the supply equation but not for demand. As for the supply equation, wages should be deflated by the cost of living in the two sectors and not by produce prices because it is wages that represent income differentials; deflation by product prices is justified only for the demand equation. Finally, as was argued

[104] Minami, *Economic Development and Cultural Change*.

in Chapter 2, the supply function should also include the ratio of the labor forces in the two sectors.

## Data Sources and Definitions

Unless otherwise indicated, the data were taken from Ohkawa and Rosovsky, *Japanese Economic Growth*.

*Migration:* Migration was computed from the following expression:

$$M_{t-1} = L_t \left\{ \frac{1+n_1}{1+n} \ell_{t-1} - \ell_t \right\}, \tag{B.2}$$

where

$\ell_t$ = share of agriculture in the labor force in year $t$,

$L_t$ = the total labor force in year $t$, and

$n_1$ and $n$ = growth rates of the labor force in agriculture and overall for the economy, respectively.

*Labor force:* This series reports "gainfully employed persons." Before 1946, that meant the "usual" occupational status of the person, but in the postwar years, it meant "employed" according to ILO's definition. Agriculture covers fishing and forestry.

The series was updated for 1971-73 by using data from the Office of Prime Minister, Bureau of Statistics, *Japan Statistical Yearbook*, various issues. The series listed under this year in the yearbook differed slightly from the main series for the years 1965-70 in which the old and new series overlap The old series was regressed on the new, and the updating was done according to the following regression:

$$\hat{y}_t = 4.43 + 0.625\ x_t.$$

For the nonagricultural labor force the regression is

$$\hat{y}_t = 1.29 + .971\ x_t.$$

The growth rate of the labor force was computed from these corrected data.

*Income differential:* This variable was computed as the ratio of the average productivity in the nonagricultural sector to that of the agricultural sector. The labor figures for that computation are taken from the series discussed above. The outputs are net sectoral domestic products at current market prices. Agriculture includes the forestry and fishing industries, and the series omits 1945.

The series were updated for 1971-73 in the same way as the labor series, using the following regressions:

For agriculture,

$$\hat{y}_t = -201{,}849.78 + 0.958\ x_t,$$

and for nonagriculture,

$$\hat{y}_t = 788{,}738.5 + 1.038\ x_t.$$

*Gross National Expenditure in constant prices:* The data are at 1934-36 prices for 1905-52, at 1960 prices for 1952-65, and at 1965 prices for 1965-70. The ratio of measures for the overlap years were then multiplied by the succeeding series to obtain 1934-36 price "equivalents." The yearly percentage changes gave the variable $g_y$ used in the analysis.

*Wages:* the wage ratio is the ratio of male manufacturing wages to male agricultural day-laborer wages, 1905-69. From 1905 to 1963, the data are from Ohkawa *et al. Estimates of Long-Term Economic Statistics of Japan since 1968,* vols. 8 and 9. From 1964 to 1969, the data are from Ministry of Labor *Yearbook of Labor Statistics.* Manufacturing data from the *Yearbook* are for enterprises of five or more employees, and wage data are monthly, not daily, rates. However, the *Yearbook* publishes estimates of average days worked per month by males in these manufacturing enterprises, and this was used to obtain daily wage rate estimates for manufacturing. The two series did not exactly coincide between 1960 and 1963. For this reason, two wage ratios were computed for this overlap period, and the average proportion of the ratio from the first source to the ratio from the second was multiplied by the *Yearbook* ratios of 1964 to 1969 to arrive at an adjusted ratio, comparable with the 1905-63 data from *Long-Term Economic Statistics.*

# APPENDIX C

## ESTIMATING SAVING RATES

In the framework of this analysis, savings are distributed between the agricultural and the nonagricultural sectors. Domestic savings are generated in households, firms, and in the public sector.[105] This analysis implicitly combines the public sector with the nonagricultural sector, and for most countries, agricultural "firms" engage primarily in agricultural production.

The problem of assigning savings to particular sectors arises with respect to households. First, there is the problem of classifying the savings pattern of households receiving income from both sectors. Basically, the question is whether differences in saving patterns, if they exist, reflect different subjective preferences or different environments; for example, uncertainty in agricultural production might lead to higher saving rates in this sector.

If it is the environment that matters, then the problem of mixed income is not relevant to the allocation of savings. If it is the difference in preferences that matters, then there is a second problem, estimating how fast preferences change. Our analysis deals with a situation of population mobility; in this case, when should a migratory household be considered urban rather than rural? All these questions must be reserved for a more refined study of savings behavior.

It is apparent that forcing a dichotomy of savings may be subject to some arbitrary decisions and possible errors. When the composition of the economy changes substantively, as is the case with the share of agriculture in the economy, it seems that the long-run structural changes are dominating, and these changes are of interest here. The assumption made in the text is that

$$s = s_1 \pi + s_2 (1-\pi), \tag{C.1}$$

where

$s$ = overall saving rate, and

$\pi$ = agricultural share of output.

This equation can be rewritten as

$$s = s_2 + (s_1 - s_2) \pi. \tag{C.2}$$

We have calculated $s$ using the equality of savings and investment from $s = I/Y$, and foreign investment is ignored. With data for $s$ *and* $\pi$, it is possible to estimate $s_1$ and $s_2$ by fitting (C.2) to the data.

[105]A discussion of the sectoral rates of savings and the importance of flow of savings in the development of Japan appears in Ohkawa, "Agricultural Policy."

It is possible to relax the assumption that saving rates are constant. This is called for by the observation that "over time, and especially in this century, the saving rates have risen sharply, especially during expansion periods."[106] To account for differences in saving rates it is assumed that:

$$s_1 = a_1 + b_1 y_1 + u_1$$
$$s_2 = a_2 + b_2 y_2 + u_2, \qquad \text{(C.3)}$$

where

$y_1, y_2$ = average incomes per worker in the two sectors, and
$u_1, u_2$ = random disturbances.

Combining (C.2) and (C.3),

$$s = a_1 + (a_2 - a_1)\,\pi_2 + b_1\pi_1 y_1 + b_2\pi_2 y_2 + u, \qquad \text{(C.4)}$$

where

$\pi_2 = 1 - \pi_1$, and
$u$ = combined error term.

Estimates of the coefficients of (C.4) for the prewar period appear in Table 23.

The estimates in regression 1 are obtained under the restriction that $b_1 = b_2 = 0$, so that (C.4) becomes identical with (C.2). Under this restriction, there is no difference between $s_1$ and $s_2$, because the coefficient of $\pi_2$ is not significantly different from zero.

The second regression assumes that $b_1 = 0$; that is, the saving rate in agriculture remains constant. Consequently, $s_1 = 0.2$, and $s_2$ is increasing with $y_2$ and $\pi$. The value of $s_2$ at the beginning of the period is 9 percent, and at the end of the period it is 16 percent. Consequently, the value of $\lambda = s_1/s_2$ varies; its average value is 1.78, with a standard deviation of 0.25.

Regressions 3 and 4 represent the full equation, (C.4). The coefficient of the product term $\pi_1 y_1$ in regression 3 is subject to a relatively large error (its $t$-ratio is 1.2). A first-order correction resulted in even lower $t$-ratios. The saving rates estimated by these two regressions are not much different from those obtained from regression 2. In conclusion, if allowance is made for changing saving rates, the present analysis suggests accepting the results of regression 2. Such results are, of course, preliminary and should be substantiated by independent sources of information.

## DATA FOR CHAPTER 4—SOURCES AND DEFINITIONS

*Flow of savings:* the relative savings flow $f$ was computed as

$$f = FS_1 = 1 - \rho_1\left(1 + \frac{(1-\pi)}{\pi\lambda}\right),$$

[106] Ohkawa and Rosovsky, *Japanese Economic Growth*, p. 167.

## Table 23—Estimating sectoral saving rates for the prewar period

| Regression Number | Intercept | $\pi_2$ | $\pi_2 y_2$[a] | $\pi_1 y_1$[a] | Auto-regression | $R^2$ | Durbin-Watson *Statistic* | Beginning and end values | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | $s_1$ | $s_2$ |
| $c_1$ | 0.087 (1.5) | 0.068 (0.9) | ... ... | ... ... | 0.609 | 0.369 | 2.0 | 0.087 | 0.087 |
| $c_2$ | 0.200 (3.6) | −0.160 (1.67) | 0.103 (2.6) | ... ... | 0.361 | 0.426 | 2.1 | 0.20 | 0.09-0.16 |
| $c_3$ | 0.166 (1.8) | −0.167 (1.4) | 0.120 (3.0) | 0.72 (1.2) | ... | 0.391 | 1.8 | 0.23-0.32 | 0.06-0.14 |
| $c_4$ | 0.220 (1.8) | −0.176 (1.1) | 0.104 (2.0) | −0.02 (0.3) | 0.416 | 0.428 | 2.1 | 0.22 | 0.09-0.17 |

Note: Numbers in parentheses are *t*-ratios.
[a]These coefficients should be divided by $10^3$.

where

$\rho_1$ = share of agriculture in investment,

$\pi$ = agriculture's share of output,

$\lambda$ = ratio of agricultural to nonagricultural saving rates, and

$S_1$ = savings generated in agriculture.

*Output shares:* Outputs are net sectoral domestic products in current market yen. The source is Ohkawa and Rosovsky, *Japanese Economic Growth.* Agriculture, here as elsewhere, includes forestry and fishing.

*Investment shares:* Investment is gross fixed domestic investment, excluding military and residential, in current yen. The source is Ohkawa *et al.*, *Long-Term Economic Statistics,* vol. 1.

*Capital:* Capital stock is defined as the "domestic aggregate of reproducible, tangible, fixed assets which constitute 'production capacity' used in producing goods and services." Thus, land, mineral resources, military stock, consumer durables, and inventories are excluded, as are residential buildings and land improvements. The unit of measurement is constant 1934-36 yen. This series was used with the output series to form a measure of relative output-capital ratios. The source for prewar data is *Long-Term Economic Statistics,* vol. 3.

*Capital shares:* The share of capital for the nonagricultural sector came directly from Ohkawa and Rosovsky, *Japanese Economic Growth.* They deducted labor costs from output to obtain this share. The data for agriculture came from Y. Hayami *et al.*[107] Hayami's shares were of total production. To obtain shares of value added, the share for current inputs was deducted and the share of capital was divided by the difference. His data were for five-year periods. The shares were computed from total costs, in which a rate of interest was assumed. Our calculations in principle should reproduce the assumed rate of interest. Thus, $\delta_r$ is not as meaningful as it would have been had it been calculated by following for agriculture the procedure used for the nonagricultural sector.[108]

*Capital returns differential:* A ratio was formed from the capital share data of the two sectors and then multiplied by a ratio of sectoral output-capital ratios to arrive at a measure of the capital returns differential. In this computation, the output series used is from Ohkawa and Rosovsky, *Japanese Economic Growth,* and is net of depreciation; the capital series is gross. The same sources were used to derive a second measure—the ratio of sectoral output-capital ratios.

---

[107] *A Century of Agricultural Growth,* p. 36.

[108] The procedure used by Hayami is described in Y. Hayami and S. Yamada, "Agricultural Growth in Japan, 1880-1970," mimeographed (n.p., 1974).

*Economic expectations:* For this, a measure of economic growth was used. The measure used for the prewar period is derived from net domestic product in constant 1934-36 market yen. The series came from Ohkawa and Rosovsky, *Japanese Economic Growth*. For the postwar period, the series used is gross national expenditure in constant 1965 yen. This series is found in *Long-Term Economic Statistics*, vol. 1. Some of the data and the measures are summarized in Table 24.

**Table 24—Summary statistics, savings flow variables**

| Variable | Prewar: 1909-38 | | Postwar: 1955-64 | |
|---|---|---|---|---|
| | Mean | Coefficient of Variation | Mean | Coefficient of Variation |
| Differential returns, $\delta_r$ | 0.254 | 0.215 | 0.509 | 0.126 |
| Differential returns, $\delta_{ar}$ | 0.859 | 0.183 | 1.141 | 0.093 |
| Ratio of product share, R | 3.392 | 0.370 | 6.453 | 0.269 |
| Transformed rate of growth | | | | |
| ($g_y$ + 1.1) | 1.137 | 0.050 | 1.205 | 0.022 |
| Relative flow of funds, $f$ | | | | |
| ($\lambda$ = 0.8) | 0.207 | 1.156 | ... | ... |
| ($\lambda$ = 1) | 0.335 | 0.588 | 0.423 | 0.092 |
| ($\lambda$ = 1.2) | 0.419 | 0.402 | ... | ... |
| ($\lambda$ = 1.5) | 0.504 | 0.278 | ... | ... |
| ($\lambda$ = 2) | 0.588 | 0.191 | ... | ... |

# APPENDIX D

## A DESCRIPTION OF THE SIMULATOR

The rate of change of the system at time $t$ can be described by

$$A(\,.\,.)\,\hat{x}(\,.\,.) = b(\,.\,.)$$

where

$(\,.\,.) = [t, x(t)]$, $x(t)$ = vector of variables whose values are determined, mostly endogenously, at time $t$,

$\hat{x}(\,.\,.)$ = vector of rates of change of the elements of $x(t)$,
$A(\,.\,.)$ = nonsingular matrix, and
$b(\,.\,.)$ = a vector of exogenous variables and parameters.

Both $A(\,.\,.)$ and $b(\,.\,.)$ are determined at $t$. A numerical solution is obtained for $\hat{x}(t) = A^{-1}b$. For each element, $x_i$, of $x$, a value is obtained for $t + 1$; that is, $x_i\,(t+1) = x_i(t)\,[1+\hat{x}_i(t)]$. $A$ and $b$ are recalculated for each year, and the process repeats itself.

Some of the difference equations were discussed in the text, and some were not. This appendix briefly describes the system that follows from the discussion in the text, which was used for the numerical results. In some places, the expressions are generalized in an obvious way. Each equation is described separately. For each equation, only the nonzero coefficients are given; those that are not explicitly defined are equal to 1. Each coefficient is denoted by a double subscript, say $a_{ij}$, where $i$ denotes the equation number (row of $A$) and $j$ denotes the variable number (column of $A$).

Starting with the production functions, for agriculture,

$$a_{1,1}\,\hat{y}_1 + a_{1,7}\,\hat{L}_1 + a_{1,10}\,\hat{A} + a_{1,11}\,\hat{L} + a_{1,12}\,\hat{K}_1 = \gamma_1, \tag{D.1}$$

and for the rest of the economy,

$$\begin{aligned} &a_{2,2}\,\hat{y}_2 + a_{2,8}\,\hat{L}_2 + a_{2,9}\,\hat{K}_2 + a_{2,11}\,\hat{L} = \hat{\gamma}_2 \\ &a_{1,7} = -\alpha_1(t), \quad a_{1,10} = \alpha_1(t)+\beta_1(t)-1, \; a_{1,12} = -\beta_1(t), \\ &a_{2,8} = -\alpha_2(t), \quad a_{2,9} = -\beta_2(t). \end{aligned} \tag{D.2}$$

The factor shares are recomputed at each time, $t$.

Equations (D.3) and (D.4) are identical to (5.28) and (5.29), respectively, and equations

(D.5), (D.6), and (D.7) are (5.34), (5.30) and (5.31), respectively. The right-hand side of those equations constitutes the elements of the $b(..)$ vector.

The value of $m(t)$ is obtained from the migration equation. The differentials of (5.7) to (5.10) yield

$$a_{8,1}\,\hat{y}_1 + a_{8,14}\,\hat{i}_1 + a_{8,17}\,\hat{s}_1 + a_{8,29}\,\hat{f} = e_8, \quad \text{and} \tag{D.8}$$
$$a_{9,2}\,\hat{y}_2 + a_{9,15}\,\hat{i}_2 + a_{9,18}\,\hat{s}_2 + a_{9,19}\,\hat{p} + a_{9,29}\,\hat{f} = e_9, \tag{D.9}$$
$$a_{8,14} = -i_1(t)/s_1(t)y_1(t), \quad a_{8,29} = -f(t)/s_1(t)y_1(t),$$
$$a_{9,15} = -i_2(t)/s_2(t)y_2(t), \quad a_{9,19} = a_{9,29} = p(t)f(t)/s_2(t)y_2(t).$$

The e elements on the right-hand side are zero unless specified exogenously to take on other values. This is done in order to accommodate policy instruments. In the case of (D.8) and (D.9), positive values for e imply investment from abroad.

Differentiating (5.5) and (5.6) yields

$$a_{10,5}\,\hat{x}_1^i + a_{10,14}\,\hat{i}_1 + a_{10,16}\,\hat{\lambda} = 0, \quad \text{and} \tag{D.10}$$
$$a_{11,6}\,\hat{x}_2^i + a_{11,14}\,\hat{i}_1 + a_{11,15}\,\hat{i}_2 + a_{11,16}\,\hat{\lambda} + a_{11,19}\,\hat{p} = 0, \tag{D.11}$$
$$a_{10,14} = a_{10,16} = -1, \; a_{11,14} = -(1+a_{11,15}),$$
$$a_{11,15} = -i_2(t)/x_2^i(t), \; a_{11,16} = \frac{-\lambda}{1-\lambda}\,a_{11,14},$$
$$a_{11,19} = a_{11,14}.$$

Differentiating (5.3) and (5.4), we get

$$a_{12,1}\,\hat{y}_1 + a_{12,13}\,\hat{x}_1^s + a_{12,5}\,\hat{x}_1^i = e_{12}, \quad \text{and} \tag{D.12}$$
$$a_{13,2}\,\hat{y}_2 + a_{13,4}\,\hat{x}_2^s + a_{13,6}\,\hat{x}_2^i = e_{13}, \tag{D.13}$$
$$a_{12,1} = -y_1(t)/x_1^s(t), \; a_{12,5} = x_1^i(t)/x_1^s(t),$$
$$a_{13,2} = -y_2(t)/x_2^s(t), \; a_{13,6} = x_2^i(t)/x_2^s(t).$$

Differentiating the demand equation, (5.19),

$$a_{14,19}\,\hat{p} + a_{14,20}\,\hat{x}_1^d + a_{14,21}\,\hat{x}_2^d = 0, \tag{D.14}$$
$$a_{14,19} = \sigma_D, \; a_{14,21} = -\eta.$$

To obtain the rate of change of the overall capital stock in value terms, ($K \equiv pK_1+K_2$), we write

$$a_{15,19}\,\hat{K}_2 + a_{15,12}\,\hat{K}_1 + a_{15,13}\,\hat{K} + a_{15,19}\,\hat{p} = 0, \tag{D.15}$$
$$a_{15,9} = K_2(t)/K(t), \; a_{15,12} = 1 - a_{15,9} = a_{15,19},$$
$$a_{15,13} = -1.$$

Equations (D.16) to (D.19) are introduced to accommodate extensions and generalizations. This can be done by making changes in the variables on the left-hand side depend on changes in other variables in the system. Otherwise, the values of the $b$'s are introduced from the outside.

$$\hat{A} = b_{16}. \tag{D.16}$$

$$\hat{\lambda} = b_{17}. \tag{D.17}$$

$$\hat{s}_1 = b_{18}. \tag{D.18}$$

$$\hat{s}_2 = b_{19}. \tag{D.19}$$

Differentiating the equilibrium conditions (5.20),

$$a_{20,4}\,\hat{x}_2^s + a_{20,21}\,\hat{x}_2^d = e_{20}, \tag{D.20}$$

$$\begin{aligned} &a_{21,3}\,\hat{x}_1^s + a_{21,20}\,\hat{x}_1^d = e_{21}, \\ &a_{20,21} = a_{21,20} = -1, \end{aligned} \tag{D.21}$$

where $e_{20}$ and $e_{21}$ are introduced to allow for disequilibrium in the commodity market.

Equations (D.22) – (D.26) are obtained by approximating the marginal productivities with constant-elasticity-of substitution-like functions. It should be noted that the approximation is of the marginal productivity rather than of the production function. This point has been mentioned in the text. Also, because the changes in factor prices are restricted by equations (D.30) and (D.31), which are described below, and factor allocations are determined independently, it turns out that the elasticities of factor substitution might be changing.

$$a_{22,1}\,\hat{y}_1 + a_{22,7}\,\hat{L}_1 + a_{22,11}\,\hat{L} + a_{22,19}\,\hat{p} + a_{22,22}\,\hat{w}_1 + a_{22,30}\,\hat{\sigma}_1 = -\gamma_{1L}\left(1 - \frac{1}{\sigma_1}\right), \tag{D.22}$$

$$a_{23,1}\,\hat{y}_1 + a_{23,11}\,\hat{L} + a_{23,12}\,\hat{K}_1 + a_{23,19}\,\hat{p} + a_{23,24}\,\hat{r}_1 + a_{23,30}\,\hat{\sigma}_1 = -\gamma_{1K}\left(1 - \frac{1}{\sigma_1}\right), \tag{D.23}$$

$$a_{24,1}\,\hat{y}_1 + a_{24,10}\,\hat{A} + a_{24,11}\,\hat{L} + a_{24,19}\,\hat{p} + a_{24,26}\,\hat{R} + a_{24,30}\,\hat{\sigma}_1 = -\gamma_{1A}\left(1 - \frac{1}{\sigma_1}\right), \tag{D.24}$$

$$a_{22,1} = a_{23,1} = a_{24,1} = -a_{22,7} = a_{22,11} = a_{23,11} = -a_{23,12} = -a_{24,10} = a_{24,11} = 1/\sigma_1(t),$$

where $\sigma_1(t)$ is the direct elasticity of substitution in sector 1, and

$$a_{22,22} = a_{23,24} = a_{24,26} = -1,\ a_{22,30} = -\ell n[Y_1(t)/L_1(t)],$$
$$a_{23,30} = -\ell n[Y_1(t)/K_1(t)],\ a_{24,30} = -\ell n[Y_1(t)/A(t)].$$

Similarly,

$$a_{25,2}\,\hat{y}_2 + a_{25,8}\,\hat{L}_2 + a_{25,11}\,\hat{L} + a_{25,23}\,\hat{w}_2 + a_{25,31}\,\hat{\sigma}_2 = -\gamma_{2L}\left(1 - \frac{1}{\sigma_2}\right), \tag{D.25}$$

$$a_{26,2}\,\hat{y}_2 + a_{26,9}\,\hat{K}_2 + a_{26,11}\,\hat{L} + a_{26,25}\,\hat{r}_2 + a_{26,31}\,\hat{\sigma}_2 = -\gamma_{2K}\left(1 - \frac{1}{\sigma_2}\right), \tag{D.26}$$

$$a_{25,2} = a_{26,2} = -a_{25,8} = -a_{26,9} = a_{26,11} = a_{25,11} = 1/\sigma_2(t),$$
$$a_{25,23} = a_{26,25} = -1 \qquad a_{25,31} = -\ell n[Y_2(t)/L_2(t)],$$
$$a_{26,31} = -\ell n[Y_2(t)/K_2(t)].$$

The restrictions on the changes in factor prices are given by (5.37) and (5 38), which are rewritten as

$$a_{30,19}\,\hat{p} + a_{30,22}\,\hat{w}_1 + a_{30,24}\,\hat{r}_1 + a_{30,26}\,\hat{R} = \gamma_1\,, \tag{D.30}$$
$$a_{31,23}\,\hat{w}_2 + a_{31,25}\,\hat{r}_2 = \gamma_2\,, \tag{D.31}$$

$$a_{30,19} = -1,\ a_{30,22} = \alpha_1(t),\ a_{30,24} = \beta_1(t),\ a_{30,26} = 1-\alpha_1(t)-\beta_1(t),\ a_{31,23} = \alpha_2(t),\ a_{31,25} = \beta_2(t).$$

Given the changes in factor prices, the changes in their ratios are

$$a_{27,24}\,\hat{r}_1 + a_{27,25}\,\hat{r}_2 + a_{27,28}\,\hat{\delta}_r = 0, \tag{D.27}$$
$$a_{28,22}\,\hat{w}_1 + a_{28,23}\,\hat{w}_2 + a_{28,27}\,\hat{\delta}_w = 0, \tag{D.28}$$
$$a_{27,25} = a_{27,28} = a_{28,23} = a_{28,27} = -1.$$

Finally, the change in the per capita flow of funds is obtained from an explicit formulation of the flow of funds equation (5.27). First note that by using (5.7) and (5.8) and expressing the left-hand side of (5.27) on a per capita basis, it can be written as $f(t)/s_1(t)y_1(t)$. An explicit formulation similar to that used for the labor migration is

$$\frac{f}{s_1 y_1} = \beta_{0f}\left(\frac{\pi_2}{\pi_1}\right)^{\beta_{1f}}\left(\frac{1}{\delta_r} - c_{1f}\right)^{\beta_{2f}} z^{\beta_{3f}},\ \text{for } \delta_r < c_{1f},$$

and

$$-\frac{f}{s_1 y_1} = \beta_{0f}\left(\frac{\pi_2}{\pi_1}\right)^{\beta_{1f}} (\delta_r - c_{1f})^{\beta_{2f}} z^{\beta_{3f}}, \text{ for } \delta_r > c_f,$$

and

$$f = 0, \text{ for } \delta_r = c_{1f}$$

The term $c_{1f}$ is a constant, determined so that when $\delta_r = c_{1f}$, there is no flow of funds. In a perfect market, $c_{1f}$ is expected to be 1. In general, it is to be determined from the data. When $\delta_r = \frac{r_1}{r_2} < c_{1f}$, f is positive; that is, funds flow from agriculture. On the other hand, when $\delta_r > c_{1f}$, funds are expected to flow to agriculture, and $-f > 0$. In what follows, we write only the differential of the first part of the equation, for $f > 0$. The variable $\delta_r$ should actually represent expectations. We shall not elaborate here on that point except to indicate that if the expectations are not related to the current values of $\delta_r$, then the simulator simplifies a great deal, because factor prices have almost no role in resource allocation.

The term $\pi_2/\pi_1$ represents the relative size of the two sectors, and the purpose is served by taking present or last year's values of $\pi$. $z$ represents exogenous variables, which are not specified here. If $b_{1f}$ etc. represent estimated values for $\beta_{1f}$ etc, and the $\pi_i(t)$ represent $\pi_i(t-1)$, then (D.29) can be written as follows:

$$a_{29,1}\hat{y}_1 + a_{29,2}\hat{y}_2 + a_{29,17}\hat{s}_1 + a_{29,19}\hat{p} + a_{29,28}\left(\frac{1}{\delta_r} - c_f\right) + a_{29,29}\hat{f} \times b_{3f}\hat{z}, \qquad \text{(D.29)}$$

$$a_{29,1} = b_{1f} - 1,\ a_{29,2} = -b_{1f} = -a_{29,19},\ a_{29,17} = -1,\ a_{29,28} = \frac{-b_{2f}}{1 - c_{1f}/\delta_r},\ a_{29,29} = 1.$$

# APPENDIX E

## INITIAL VALUES OF PARAMETERS AND VARIABLES USED IN CHAPTER 5

The empirical exercise in Chapter 5 is based on the following initial values. The values are basically those of Japan in 1905. The sources and methods of deriving unpublished data are omitted in order to avoid the impression that the purpose of the exercise is to reconstruct Japanese economic history.

| Notation | Definition | Value |
|---|---|---|
| A | Cultivated land | 5.344 |
| $\hat{A}$ | Rate of changed land | 0.007 |
| $\alpha_1$ | Labor share in $A$ | 0.557 |
| $\alpha_2$ | Labor share in $N$ | 0.576 |
| $b_{0m}$ | Intercept migration equation | − 3.755 |
| $b_{2f}$ | Exponent of $(r_2/r_1 - c_{1f})$, flow equation | 0 |
| $b_{2m}$ | Exponent of $(w_2/w_1 - c_{1m})$, migration equation | 0.232 |
| $b_{1f}$ | Exponent of $\Pi_2/\Pi_1$, flow equation | 0 |
| $b_{1m}$ | Exponent of $(L_2/L_1)$, migration equation | 0.372 |
| $b_{3m}\ell nz$ | Effect of natural growth rate on migration | 0.141 |
| $\beta_1$ | Capital share in $A$ | 0.108 |
| $\beta_2$ | Capital share in $N$ | 0.424 |
| $c_{1f}$ | See definition of $b_{2f}$ | 0 |
| $c_{1m}$ | See definition of $b_{2m}$ | 0.85 |
| $\delta_r$ | $r_1/r_2$ | 0.1343 |
| $\delta_w$ | $w_1/w_2$ | 0.416 |
| $\Delta$ | Depreciation rate | 0.03 |
| $\eta$ | "Income elasticity" | 0.3 |
| F | Flow of funds from agriculture | 17.2 |
| $\gamma_{1A}$ | Rate of land-augmenting technical change in $A$ | 0.0152 |
| $\gamma_{1k}$ | Rate of capital-augmenting technical change in $A$ | 0.0152 |
| $\gamma_{1L}$ | Rate of labor-augmenting technical change in $A$ | 0.0152 |
| $\gamma_{2k}$ | Rate of capital-augmenting technical change in $N$ | 0.0167 |
| $\gamma_{2L}$ | Rate of labor-augmenting technical change in $N$ | 0.0167 |

[109]A denotes cultivated land as well as agriculture; N stands for nonagriculture.

| | | |
|---|---|---|
| $I_1$ | Investment in $A$ | 100.94 |
| $I_2$ | Investment in $N$ | 274.75 |
| $K_1$ | Capital stock in $A$ | 3679 |
| $K_2$ | Capital stock in $N$ | 4242 |
| $L_1$ | Labor force in $A$ | 16.2 |
| $L_2$ | Labor force in $N$ | 8.799 |
| $\lambda$ | Proportion of $A$'s investment produced in $A$ | 0.616 |
| $\hat{\lambda}$ | Rate of change in $\lambda$ | − 0.018 |
| $n_1, n_2$ | Natural rates of population growth in $A$ and $N$, respectively | 0.013 |
| $p$ | Price ratio, $p_1/p_2$ | 1 |
| $R$ | Land rent | 53.66 |
| pop | Population | 46.75 |
| $\sigma_1$ | Direct elasticity of substitution, $A$ | 1.2 |
| $\sigma_2$ | Direct elasticity of substitution, $N$ | 0.8 |
| $\sigma_D$ | "Price elasticity" of demand | 0.6 |
| $s_1$ | Saving rate in $A$ | 0.138 |
| $\hat{s}_1$ | Rate of change in $s_1$ | 0 |
| $s_2$ | Saving rate in $N$ | 0.138 |
| $\hat{s}_2$ | Rate of change in $s_2$ | 0 |
| $w_1$ | Wage rate in $A$ | 29.42 |
| $w_2$ | Wage rate in $N$ | 122.40 |
| $Y_1$ | $A$ output | 856 |
| $Y_2$ | $N$ output | 1870 |

# APPENDIX F

## DATA SOURCES FOR CHAPTER 6

*Output:* Output is sectoral gross domestic product. For all variables, agriculture includes forestry and fisheries. The source for prewar output is *Long-Term Economic Statistics of Japan,* vol. 1;[110] for postwar output, it is Denison and Chung (1976).[111] The *Long-Term Economic Statistics* does not carry GDP in current yen. The series is reported in 1934-36 average constant yen. It was converted to 1907 constant yen by using a five-year average deflator centered on 1907. This was obtained from the *Long-Term Economic Statistics* net domestic product series in current and constant 1934-36 yen. The same process was carried out on the postwar data (except that the deflator was for the GDP series, both of which exist) to obtain constant 1955 yen from the original constant 1965 yen series.

*Price:* The ratio of the agricultural to the nonagricultural GDP deflators (as described above) was used for this variable.

*Labor force:* The series, from Ohkawa and Rosovsky,[112] reports "gainfully employed" persons. Prior to 1946, this meant the "usual" occupational status of the person; in the postwar years, the classification was in accordance with the ILO definitions of "employed" persons.

*Capital:* Gross capital stock is defined as the "domestic aggregate of reproducible, tangible, fixed assets which constitute 'production capacity' used in producing goods and services." Thus land, mineral resources, military stock, consumer durables, and inventories are excluded, as are residential buildings and land improvements.

For the prewar period, the source is *Long-Term Economic Statistics,* vol. 3. The original units, constant 1934-36 yen, are transformed into constant 1907 yen by multiplying by 1907-centered five-year average sectoral investment deflators. These deflators are obtained from current and constant 1934-36 average yen series for gross domestic fixed investment. The two series are from *Long-Term Economic Statistics,* volume 1.

For the postwar period, no investment-specific deflators are available from Denison and Chung. Consequently, the 1955 sectoral output deflators were used. The data source for the postwar period is Ohkawa and Rosovsky. Because the data were in constant 1960 yen, they were multiplied by the sectoral ratios of the 1955 output

[110] K. Ohkawa, M. Shinohara, and M. Umemura, eds.; *Estimates of Long-Term Economic Statistics of Japan,* since 1868, (Tokyo: Toyo keizai shinpo sha, 1965).

[111] E. Denison and W. Chung, *How Japan's Economy Grew So Fast: The Sources of Postwar Expansion* (Washington, D.C.: Brookings Institution, 1976).

[112] *Japanese Economic Growth.*

deflator (1965 yen base) to the 1960 output deflator, all in five-year averages.

*Capital shares:* The output share of capital for nonagriculture came directly from Ohkawa and Rosovsky. They deducted labor costs from output to obtain this share.

For agriculture, the data came from Hayami *et al.*[113] These shares were of total cost. To obtain shares of value added, the share of current inputs was deducted and the share of capital was divided by the difference. Their data were for five-year periods. The shares were computed from total costs, in which a rate of interest was assumed. Our calculations in principle should reproduce the assumed rate of interest. Thus, $\delta_r$ is not as meaningful as it would have been had it been calculated by following in agriculture the procedures used for the nonagricultural sector.

*Investment:* The series is gross domestic fixed investment. As for capital, it excludes military and residential investment. For the prewar period, the source is *Long-Term Economic Statistics*, vol. 1, and for the postwar period, Ohkawa and Rosovsky.

*Technical change:* The source for agriculture is Hayami *et al.* For nonagriculture, the source is Ohkawa and Rosovsky.

*Trade:* The source is Ohkawa and Rosovsky.

*"Income" and "price elasticities" of demand:* For both demand parameters, there was little guidance. Kaneda had conducted a major study of food demand, but there was no guide to nonagricultural and nonfood agricultural demand price and income elasticities. Because of this, initial values were "guesstimates." Different values were tried, and those used were the ones that produced patterns of behavior in the key endogenous variables (particularly price) that were reasonably consistent with available data.

*Direct elasticities of substitution:* Values were those used by Kelley, Williamson, and Cheetham.[114] Note that the model with data in the range used in this study is insensitive to values of these parameters.

*Depreciation:* There was no guidance, so this parameter was varied to produce better agreement between endogenous growth of capital stock and observed data.

*Proportion of A investment originating in A:* This came from investment data from *Long-Term Economic Statistics*. The proportion of agricultural investment going to livestock and perennial crops was used as a proxy for lambda, the proportion of investment in the agricultural sector originating in agriculture. Lambda hat was calculated from time series data of lambda.

*Labor force and population growth rates:* Calculated from data in Ohkawa and Rosovsky.

---

[113] *A Century of Agricultural Growth*, p. 36.

[114] *Dualistic Economic Development*.

The initial values (five-year moving averages centered at the indicated years) of the variables and of the parameters used for the basic runs appear in Table 25.

**Table 25—Initial values of variables and parameters for basic runs**

| Variable | 1907 Unit | 1907 Level | 1955 Unit | 1955 Level |
|---|---|---|---|---|
| Cultivated land ($A$) | Million cho | 5.382 | Million cho | 5.977 |
| Rate of change of land ($\hat{A}$) | | 0.7 | | 0.0 |
| A labor share ($\alpha_1$) | | 0.557 | | 0.6439 |
| N labor share ($\alpha_2$) | | 0.576 | | 0.745 |
| A capital share ($\beta_1$) | | 0.108 | | 0.1195 |
| N capital share ($\beta_2$) | | 0.424 | | 0.255 |
| Migration equation intercept ($b_{0m}$) | | −4.8 | | −3.755 |
| Exponent of $L_2/L_1$ ($b_{1m}$) | | 0.232 | | 0.232 |
| Exponent of ($\delta_w - c_{1m}$) ($b_{2m}$) | | 0.372 | | 0.372 |
| Addition from other variables ($b_{3m}\ell nz$) | | 0.141 | | 0.141 |
| $c_{1m}$ | | 0.85 | | 0.85 |
| Exponent of $\pi_2/\pi_1$ ($b_{1f}$) | | −0.17 | | −0.344 |
| Exponent of ($\delta_r - c_{1f}$) ($b_{2f}$) | | −0.091 | | −0.549 |
| $c_{1f}$ | | 0 | | 0 |
| $r_1/r_2$ ($\delta_r$) | | 0.1821 | | 0.2393 |
| $w_1/w_2$ ($\delta_w$) | | 0.3084 | | 0.2298 |
| Depreciation rate ($\Delta$) | Percent | 2.3 | Percent | 1.0 |
| Rate of change of A net imports (E12) | Percent | 0.35 | Percent | 0 |
| Rate of change of N net imports (E13) | Percent | 0.045 | Percent | 0 |
| "Income elasticity" ($\eta$) | Percent | 0.25 | Percent | 0.25 |
| Flow of funds from A (F) | Million yen | 56.304 | Billion yen | 67.88 |
| Rate of land-augmenting technical change in A ($\gamma_{1A}$) | Percent | 1.1 | Percent | 4.0 |

**Table 25—continued**

| | | | | |
|---|---|---|---|---|
| Rate of capital-augmenting technical change in A ($\gamma_{1K}$) | Percent | 1.1 | Percent | 4.0 |
| Rate of labor-augmenting technical change in A ($\gamma_{1L}$) | Percent | 1.1 | Percent | 4.0 |
| Rate of capital-augmenting technical change in N ($\gamma_{2K}$) | Percent | 0.75 | Percent | 5.25 |
| Rate of labor-augmenting technical change in N ($\gamma_{2L}$) | Percent | 0.75 | Percent | 5.25 |
| Investment in A ($I_1$) | Million yen | 116.0 | Billion yen | 328.417 |
| Investment in N ($I_2$) | Million yen | 363.244 | Billion yen | 1789.405 |
| Capital stock in A ($K_1$) | Billion yen | 3.901 | Trillion yen | 6.17 |
| Capital stock in N ($K_2$) | Billion yen | 4.963 | Trillion yen | 18.7873 |
| Labor force in A ($L_1$) | Millions | 16.089 | Millions | 16.27 |
| Labor force in N ($L_2$) | Millions | 9.141 | Millions | 24.8 |
| Proportion of A investment produced in A $\lambda$) | | 0.616 | | 0.50 |
| Rate of change in $\lambda$ ($\hat{\lambda}$) | Percent | −1.8 | Percent | 0 |
| Rate of change of A labor force ($n_1$) | Percent | 0.75 | Percent | 1.5 |
| Rate of change of N labor force ($n_2$) | Percent | 0.75 | Percent | 1.5 |
| Price ratio ($p_1/p_2$) | | 1.0 | | 1.0 |
| Population | Millions | 47.72 | Millions | 89.1 |
| Rate of change of population | Percent | 1.3 | Percent | 1.1 |
| Land rent ($R$) | Yen/cho | 76.607 | Thousand yen/cho | 47.538 |
| Direct elasticity of substitution A($\sigma_1$) | | 1.2 | | 1.2 |
| Direct elasticity of substitution N ($\sigma_2$) | | 0.8 | | 0.8 |
| Price elasticity of demand ($\sigma_D$) | | 1.2 | | 0.9 |
| Saving rate in A ($s_1$) | Percent | 14.0 | Percent | 33.0 |
| Rate of change of $s_1$ ($\hat{s}_1$) | Percent | 0.75 | | 2.0 |
| Saving rate in N ($s_2$) | Percent | 14.0 | | 25.0 |
| Rate of change of $s_2$ ($\hat{s}_2$) | Percent | 2.0 | | 3.0 |

**Table 25—continued**

| | | | | |
|---|---|---|---|---|
| Wage rate in A ($w_1$) | Yen | 42.608 | Thousand yen | 47.527 |
| Wage rate in N ($w_2$) | Yen | 138.151 | Thousand yen | 206.861 |
| A output ($Y_1$) | Billion yen | 1.2307 | Trillion yen | 1.2009 |
| N output ($Y_2$) | Billion yen | 2.1924 | Trillion yen | 6.8861 |

All of the migration equation parameters were set equal to zero in the no-migration and the no-migration/no-flow-of-funds runs. The additional restrictions imposed for the no-flow-of-funds and the no-migration/no-flow-of-funds runs appear in Table 26.

**Table 26—Restrictions imposed for completion of Tables 16 and 17**

| | 1907[a] | | 1955 | |
|---|---|---|---|---|
| Variable | Basic Run | Restricted Runs | Basic Run | Restricted Runs |
| Exponent of $\pi_2/\pi_1$ ($b_{1t}$) | −0.17 | 0 | −0.344 | 0 |
| Exponent of ($\delta_r - c_{1t}$) ($b_{2t}$) | −0.091 | 0 | −0.549 | 0 |
| Flow of funds (F) | 56.304 | 0 | 67.88 | 0 |
| Investment in A ($I_1$) | 116.0 | 172.304 | 328.417 | 396.297 |
| Investment in N ($I_2$) | 363.244 | 306.94 | 1789.405 | 1721.525 |

[a]Levels of data same as for basic runs.

For the prewar run with postwar rates of technical change, 4 percent was substituted for 1.1 percent for $\gamma_{1A}$, $\gamma_{1K}$, $\gamma_{1L}$ and 5.25 percent was substituted for 0.75 percent for $\gamma_{2K}$, $\gamma_{2L}$. For the postwar run with prewar rates of technical change, the opposite changes were made; i.e., 1.1 percent was substituted for 4 percent for A, and 0.75 percent for 5.25 percent for N. The restrictions imposed for the prewar run using postwar saving rates and the postwar run using prewar saving rates appear in Table 27.

**Table 27—Restrictions imposed for completion of Tables 18 and 19**

| | 1907 | | 1955 | |
|---|---|---|---|---|
| Variable | Basic Run | Restricted Runs | Basic Run | Restricted Runs |
| Saving rate in A ($s_1$) | 14.0 | 37.0 | 33.0 | 14.0 |
| Rate of growth of $s_1$ ($\hat{s}_1$) | 0.75 | 0.0 | 2.0 | 0.75 |
| Saving rate in N ($s_2$) | 14.0 | 30.0 | 25.0 | 14.0 |
| Rate of growth of $s_2$ ($\hat{s}_2$) | 2.0 | 0.0 | 3.0 | 2.0 |
| Investment in A ($I_1$) | 116.0 | 399.07 | 328.417 | 100.246 |
| Investment in N ($I_2$) | 363.244 | 714.03 | 1789.405 | 1031.934 |

The initial values for the prewar basic run differ in most cases from the initial values in Chapter 5. In the last chapter, the initial year was 1905, not 1907, and annual, not five-year average, data were used. This change accounts for most of the differences. In addition, several parameters were changed to improve the simulation of the actual experience as reflected in data we used. These were: the migration equation intercept ($b_{0m}$), the rates of technical change, the sectoral saving rates (which in Chapter 5 were equal between sectors for the entire run) and their growth rates, the demand parameters ($n, \sigma_D$), the net import growth rates ($E_{12}, E_{13}$), and the differences between population and labor force growth rates. (There were no differences in Chapter 5). One other change was in the parameters for the flow of funds equation. In Chapter 5, flow was kept constant by assuming zeros for the parameters of the flow equation. In addition, a slight change was made in the structure of this equation for Chapter 6.

## BIBLIOGRAPHY


Arrow, K. J. *et al.* "Capital Labor Substitution and Economic Efficiency." *Review of Economics and Statistics* 43 (1961): 225-50.

Bishop, C. E. "Economic Aspects of Changes in Farm Labor Force." In *Labor Mobility and Population in Agriculture*. By Iowa State University of Science and Technology, Center for Agricultural and Economic Adjustment. Ames: Iowa University Press, 1961.

Bowles, G. K. *Farm Population—Net Migration from the Rural-Farm Population 1940-1950.* USDA Agricultural Marketing Service, Statist. Bulletin #176, Washington, D.C., June 1956.

Chenery, H. B. and Syrquin, M. *A Pattern of Development 1950-1970.* London: Oxford University Press, 1975.

Clark, C. *Conditions of Economic Progress,* 3rd ed. New York: Macmillan Co., 1957.

Denison, E. and Chung, W. *How Japan's Economy Grew So Fast: The Sources of Postwar Expansion.* Washington, D.C.: Brookings Institution, 1976.

Gavan, J. D. "Migration and Economic Opportunities in Chile." Mimeographed. Cambridge: Center for Population Studies, Harvard University, n.d.

Gerschenkron, A. *Economic Backwardness in Historical Perspective.* Cambridge: Harvard University Press, 1962.

Gisser, M. "Schooling and the Farm Problem." *Econometrica* 33 (1965): 582-92.

Greenwood, M. J. "Research on Internal Migration in the United States: A Survey," *Journal of Economic Literature* 13 (1975): 397-433.

Harris, J. R. and Todaro, M. P. "Migration, Unemployment and Development: A Two-Sector Analysis." *American Economic Review* 60 (1970): 126-42.

Hathaway, D. E. "Migration from Agriculture: The Historical Record and its Meaning." *American Economic Review* 50 (1960): 379-91.

————. "Improving the Search for Employment." Paper presented to the Conference on Creating Opportunities for Tomorrow, 1968.

Hayami, Y. *et al. A Century of Agricultural Growth in Japan: Its Relevance to Asian Development.* Minneapolis: University of Minnesota Press, 1975.

Hayami, Y., and Yamada, S. "Agricultural Growth in Japan, 1880-1970." Mimeographed. n.p., 1974.

Houthakker, H. S. "An International Comparison of Household Expenditure Patterns: Commemorating the Centenary of Engel's Law." *Econometrica* 25 (1957): 532-51.

———. "Disproportional Growth and the Intersectoral Distribution of Income." In *Relevance and Precision, From Quantitative Analysis to Economic Policy: Essays in honor of Pieter de Wolff.* Edited by Cramer, J. S.; Heertje, A.; and Venekamp, P. E. Alphen aan den Rijn: Samsom, New York, North Holland, 1976.

IBRD. *World Tables.* Washington, D.C., 1975.

ILO. *Labor Force Projections 1965-1985,* Geneva.

ILO. *Yearbook of Labor Statistics,* Geneva, various issues.

Ishikawa, S. N. *Economic Development in Asian Perspective.* Kinokuniya Bookstore Co., 1967.

Japan Ministry of Labor. *Yearbook of Labor Statistics,* various issues.

Japan Office of Prime Minister, Bureau of Statistics. *Japan Statistical Yearbook,* various issues.

Johnson, C. D. "Functioning of the Labor Market." *Journal of Farm Economics* 33 (1951): 75-87.

Johnson, D. G. *World Agriculture in Disarray.* London: Macmillan, 1973.

Johnson, H. "Factor Market Distortions and the Shape of the Transformation Curve." *Econometrica* 34 (1966): 686-98.

Johnston, B. F., "Agriculture and Structural Transformation in Developing Countries: A Survey of Research." *Journal of Economic Literature* 2 (1970): 369-404.

Johnston, W. E. "Projecting Occupational Supply Response." In *Study of U.S. Agricultural Adjustments.* Edited by G. S. Tolley. Raleigh: North Carolina State University, n.d.

Johnston, W. E. and Tolley, G. S. "The Supply of Farm Operators." *Econometrica,* 36 (1968): 365-82.

Jorgenson, D. W. "The Development of a Dual Economy." *Economic Journal* 71 (1961): 309-34.

Kelley, A. C. and Williamson, J. G. *Lessons from Japanese Development.* Chicago University Press, 1974.

Kelley, A. O.; Williamson, J. G.; and Cheetham, R. *Dualistic Economic Development.* Chicago: University of Chicago Press, 1972.

Kuznets, S. "Quantitative Aspects of the Economic Growth of Nations, II: Industrial Distribution of National Product and Labor Force." *Economic Development and Cultural Change* 5 (supplement 1957): I-III.

———. *Six Lectures on Economic Growth.* Glencoe: Ill.: Free Press, 1959.

———. *Modern Economic Growth, Rate Structure and Spread.* New Haven: Yale University Press, 1966.

———. *Economic Growth of Nations: Total Output and Production Structure.* Cambridge: Harvard University Press, 1971.

Lewis, W. A., "Economic Development with Unlimited Supplies of Labor," *The Manchester School of Economics and Social Studies*, 22 (1954): 139-91.

————. *The Theory of Economic Growth*. London: Allen and Unwin, 1955.

————. "Unlimited Labor: Further Notes." *The Manchester School of Economics and Social Studies* 26 (1958): 1-32.

Lluch, C., *Theory of Development in Dual Economies: A Survey*. Mimeographed. Washington, D.C.: The World Bank, 1977.

Magee, S. P., "Factor Market Distortion and Trade: A Survey." *Oxford Economic Papers* 25 (1973): 1.

Masui, Y. "The Supply Price of Labor: Farm Family Workers." In *Agriculture and Economic Growth: Japan's Experience*. Edited by K. Ohkawa, B. F. Johnston, and H. Kaneda. Princeton, N.J.: Princeton University Press, 1969.

Meade, J. *A Neo-Classical Theory of Economic Growth*. New York: Oxford University Press, 1961.

Mellor, J. W. *The New Economics of Growth: A Strategy for India and the Developing World*. Ithaca and London, Cornell University Press, 1976.

Minami, R. "Population Migration Away from Agriculture in Japan." *Economic Development and Cultural Change*, 15 (1967): 183-201.

————. "The Supply of Farm Labor and the 'Turning Point' in the Japanese Economy." In *Agriculture and Economic Growth: Japan's Experience*. Edited by K. Ohkawa, B. F. Johnston, and H. Kaneda. Princeton, N.J.: Princeton University Press, 1969.

Misawa, T. "An Analysis of Part-Time Farming in the Postwar Period." In *Agriculture and Economic Growth: Japan's Experience*. Edited by K. Ohkawa, B. F. Johnston and H. Kaneda. Princeton, N.J.: Princeton University Press, 1969.

Mundlak, Y. "On Microeconomic Theory of Distributed Lags." *The Review of Economics and Statistics* 48 (1966): 51-60.

Mundlak, Y. "The Terms of Trade of Agriculture in Context of Economic Growth." In *Economic Problems of Agriculture in Industrial Societies*. Edited by U. Papi and L. Nunn. New York: St. Martin's Press, 1969.

Mundlak, Y. and Mosenson, R. "Two-Sector Model with Generalized Demand." *Metroeconomica* 22 (1970): 227-58.

Ohkawa, K. "Agricultural Policy: The Role of Agriculture in Early Economic Development." In *Economic Development with Special Reference to East Asia*. Edited by K. Berrill. New York: St. Martin's Press, 1964.

Ohkawa, K. *Differential Structure and Agriculture: Essays on Dualistic Growth*. Tokyo: Kinokuniuya Bookstore Co., 1972.

Ohkawa, K.; Johnston, B.; and Kaneda, H.; eds. *Agriculture and Economic Growth: Japan's Experience*. Princeton, N.J.: Princeton University Press, 1970.

Ohkawa, K., and Rosovsky, H. "The Role of Agriculture in Modern Japanese Economic Development." *Economic Development and Cultural Change* 9 (1960): 43-67.

———. *Japanese Economic Growth: Trend Acceleration in the Twentieth Century.* Stanford, Ca.: Stanford University Press, 1973.

Ohkawa, K.; Shinohara, M.; and Umemura, M.; eds. *Estimates of Long-Term Economic Statistics of Japan, Since 1868.* Vols. 1, 2, 3, 4, 8, 9. Tokyo: Toyo keizai shinpo sha, 1965.

Ranis, G., and Fei, J. C. H. "A Theory of Economic Development," *American Economic Review* 51 (1961): 533-65.

Schuh, E. G. "The New Macroeconomics of Agriculture, *American Journal of Agricultural Economics* 58 (1976): 802-11.

Schultz, T. W. *Transforming Traditional Agriculture.* New Haven: Yale University Press, 1964.

———. *Economic Growth and Agriculture.* New York: McGraw-Hill, 1968.

Schwartz, A. "Migration, Age and Education," *Journal of Political Economics* 84 (1976): 701-20.

Sen, A. K. "Neo-Classical and Neo-Keynesian Theories of Distribution," *The Economic Record* 36 (1963): 53-64.

Sjaastad, L. A. "Occupational Structure and Migration Patterns," *Labor Mobility and Population in Agriculture.* Ames: Iowa University Press, 1961.

———. "The Cost and Returns of Human Migration," *Journal of Political Economics* 70 (Supplement 1962): 80-93.

Solow, R. M. "Investment and Technical Progress." In *Mathematical Methods in the Social Sciences.* Edited by K. Arrow *et al.* Stanford: Stanford University Press, 1960.

———. "Technical Progress, Capital Formation and Economic Growth." *American Economic Review* (1969): 76-86.

Teranishi, J. "The Pattern and Role of Flowing Funds Between Agriculture and Nonagriculture in Japanese Economic Development." Mimeographed. n.p., n.d.

Todaro, M. P. "A Model of Labor Migration and Urban Unemployment in Less Developed Countries." *American Economic Review* 59 (1969): 138-48.

———. "Labor Migration and Urban Employment: Reply." *American Economic Review* 60 (1970): 126-142.

Tropp, Z. and Mundlak, Y. "Distortion in the Factor Market and the Short Run Equilibrium." Discussion Paper 454. Cambridge: Harvard Institute of Economic Research, 1976.

Tussing, A. R. "The Labor Force in Meiji Economic Growth: A Quantitative Study of

Yamanashi Prefecture." in *Agriculture and Economic Growth: Japan's Experience*. Edited by K. Ohkawa, B. F. Johnston, and H. Kaneda. Princeton, N.J.: Princeton University Press, 1969.

Umemura, M. "Agriculture and Labor Supply in the Meiji Era. "In *Agriculture and Economic Growth: Japan's Experience*. Edited by K. Ohkawa, B. F. Johnston, and H. Kaneda. Princeton, N.J.: Princeton University Press, 1969.

United Nations. *Demographic Yearbook*. New York, various issues.

————. *National Accounts Yearbook*. New York, various issues.

Yamada, S. and Hayami, Y. "Growth Rates of Japanese Agriculture, 1880-1965." Mimeographed. The Food Institute, East-West Centre, University of Hawaii, and Economic Development Center, University of Minnesota, 1972.

Yoshihara, K. "Demand Functions: An Application to the Japanese Expenditure Pattern." *Econometrica* 37 (1969): 257-74.

Zarembka, P. "Labor Migration and Urban Unemployment: Comment." *American Economic Review*. 60 (1960): 184-86.

Yair Mundlak of the Hebrew University of Jerusalem joined IFPRI as a Visiting Researcher in 1976. Currently he is Visiting Professor of Economics at the University of Chicago. He has been Visiting Professor of Economics at Harvard University and Dean of the Faculty of Agriculture at the Hebrew University. Yair Mundlak has made important contributions to the fields of agricultural economics and econometrics.