Writing History Backwards: Meiji Japan Revisited
Author(s): Allen C. Kelley and Jeffrey G. Williamson
Source: *The Journal of Economic History*, Vol. 31, No. 4 (Dec., 1971), pp. 729-776
Published by: Cambridge University Press on behalf of the Economic History Association
Stable URL: http://www.jstor.org/stable/2117208
Accessed: 22/08/2009 20:10

THE JOURNAL OF ECONOMIC HISTORY

VOLUME XXXI DECEMBER 1971 NUMBER 4

Writing History Backwards: Meiji Japan Revisited

In following the paths of historical development . . . the analyst finds himself . . . engaged in the rather thankless task of trying to derive known from unknown or, at least, better-known from less well-known facts. Would it not be much more efficient to reverse this procedure? By establishing the base of his operations, that is, the principal store of primary factual information in the present or a very recent past, and then moving on backward with the help of theoretical weapons step by step toward the more and more distant past, the analytical historian could make most effective use of the limited amount of direct factual information to which he usually has access.

Wassily Leontief, *Essays in Economics: Theories and Theorizing* (Oxford University Press: New York, 1966), p. 16

WRITING ECONOMIC HISTORY BACKWARDS

THIS article applies a dynamic macro economic model to Japanese economic history. It asks the traditional question: what are the lessons of history? While it is not yet another essay in methodology by new economic historians, the approach is sufficiently unconventional to require an early clarification and defense.

The use of general equilibrium interdependent systems is no longer uncommon in historical research.[1] However, with few ex-

The research reported in this paper was financed by a grant from the National Science Foundation (GS 1837) and the University of Wisconsin Graduate School. It has benefited from the helpful comments of Russell J. Cheetham, Colin Clark, Jack Dowie, John McCarty, Alan Powell, Henry Rosovsky, R. P. Sinha, Joseph A. Swanson, Kozo Yamamura, our colleagues at the University of Wisconsin, and the participants at the Cliometrics Conference held at Madison, Wisconsin (April 29-May 1, 1971).

[1] See, for example: Jerry Green, "The Effect of the Iron Tariff in the United States 1847-1859: The Estimation of a General Equilibrium System with Non-Traded Goods;" Peter Passell and Maria Schmundt, "Pre-Civil War Land Policy

ceptions, these applications are restricted to comparative statics. The present study is concerned instead with dynamics, the predominant focus of the historian. The analytical framework developed here has its roots in growth theory and is capable of explaining historical experience of a country in terms of its per capita income growth, income distribution, and structural change. The model itself has a structure relevant to low-income, land-poor, developing Asian economies and is sufficiently complex to make qualitative analysis impossible. We do not view this as a limitation, however, since as economic historians we are concerned with a very special economy at a specific point in time: Meiji Japan, 1880-1915.

Simulation analysis is the main analytical tool used in the study. But before we can ask historical counterfactuals and draw out the "lessons of history" as reflected in the model, we must first attempt to test its historical applicability. The critical step in this exercise is *not* our ability to estimate parameters in the modelled economy from the limited extant data, but instead to generate a quantitative historical description of Japan from the simulated model which closely conforms with actual Japanese growth experience during the Meiji period.

In a sense, this is really an attempt to write Meiji Japanese economic history *backwards*. Since the analytical economic historian will always be faced with severe data constraints in estimating economic parameters, why not estimate them with data drawn from more contemporary experience where the quantitative evidence is more abundant? The standard answer, of course, is that parameters may have changed dramatically through time. But if this is true, then how can the lessons of economic history be relevant to contemporary problems; for example, how can the "Japanese model" be applied to current development problems in Southeast Asia? If indeed the interest of the economic historian is to generalize from the past, then clearly the research process may be considered in reverse. This is accomplished by estimating parameter values and selecting initial conditions from *contemporary* Southeast Asia and then examining whether the numerical model

and the Growth of Manufacturing;" and Clayne Pope, "The Effect of the Ante-Bellum Tariff on Income Distribution," all presented to the Cliometric Conference, Madison, Wisconsin (1970).

can reproduce Meiji Japanese history where we select a starting point in the 1880's, which coincides with contemporary Southeast Asian initial conditions. If this attempt is successful, then Japanese economic history can be utilized with greater confidence as a "relevant" application to contemporary problems.

THE CONTROVERSY OVER FACT: A JAPANESE MIRACLE?

Competing Theories and the "Japanese Model"

The statistics on early historical experience with industrialization and growth are fragmentary and of doubtful quality. This generalization holds for many contemporary developing nations, for American growth in the ante-bellum period, for British industrialization experience in the late eighteenth century, and for Meiji Japan as well. Indeed, the attempts to reconstruct modern Japanese economic history have been shrouded in an unusually intense data controversy. This debate has been concerned even with such fundamental facets of Japanese development as the role of agriculture in modern economic growth. The history of western economies suggests that an agricultural revolution and a subsequent rise in agricultural productivity may often be viewed as prerequisites for modern economic growth and industrialization.[2] This has been termed the "prerequisite" hypothesis. With the appearance of quantitative Japanese research by such scholars as Ohkawa and Rosovsky, the prerequisite thesis has been vigorously challenged. Based on official agricultural statistics, Johnston, Ohkawa, Rosovsky and others have argued that Japanese experience was unique. Not only did the Japanese record in the Meiji period suggest "miraculous" growth performance, but the rapid expansion of agricultural productivity from levels comparable to contemporary monsoon Asia took place simultaneously with industrialization. This thesis diminishes the importance of agricultural revolutions as a prerequisite to modern economic growth and stresses instead the *concurrent* growth of agriculture and industry. An index of

[2] Much of the following paragraph is taken from the excellent summary in Yujiro Hayami and Saburo Yamada, "Agricultural Productivity at the Beginning of Industrialization," in K. Ohkawa, Bruce F. Johnston, and H. Kaneda, editors, *Agriculture and Economic Growth: Japan's Experience* (Tokyo: University of Tokyo Press, 1969), pp. 105-135.

the wide-spread acceptance of the Johnston-Ohkawa-Rosovsky characterization of Meiji economic history is the frequent reference to the "Japanese model" of development.[3]

Nakamura and others before him have sharply questioned the uniqueness of the Japanese growth experience both in relation to the "miraculous" overall rates of progress and in relation to the Johnston-Ohkawa-Rosovsky interpretation of agriculture's role in Asian development.[4] Nakamura has persuasively argued that the Ohkawa estimates greatly understate the level of agricultural production beginning in 1878-1882; moreover, this understatement, resulting from biases in official government statistics due to tax evasion practices, diminishes over time. The result is a significant overstatement in the growth rate of Japanese agriculture. Nakamura's estimates show agricultural output expanding at an annual rate of around 1 percent from 1878-1882 to 1913-1917; a comparable figure compiled from the Ohkawa series is 2.4 percent.[5] Even though Nakamura has not assembled new estimates for secondary and tertiary production, he asserts that the growth rate in these sectors is also overstated due to the widespread monetization of production during the Meiji period. Given the importance of the agricultural sector, Nakamura's competing estimates reduce the Ohkawa aggregate annual growth rate for Japan, 1878-1882 to 1913-1917, from 4.0 to 2.8 percent. If possible biases in secondary and tertiary production were also taken into account, the aggregate growth rate would be even lower, perhaps as low as 1 or 2 percent.[6]

Yet the debate over measurement may have obscured many theoretical issues which are critically important to the economic historian and development economist. The motivation of this paper is *not* to add further fuel to the data debate but instead to explore analytically several questions which are less dependent on the outcome of that debate. These questions are confronted in a later

[3] Henry Rosovsky, "Rumbles in the Ricefields: Professor Nakamura vs. the Official Statistics," *The Journal of Asian Studies*, XXVII (Feb. 1968), 360.

[4] James I. Nakamura, "Growth of Japanese Agriculture, 1875-1920," in W. W. Lockwood, editor, *The State and Economic Enterprise in Japan* (Princeton: Princeton University Press, 1965), ch. vi. See also James I. Nakamura, *Agricultural Production and the Economic Enterprise in Japan* (Princeton: Princeton University Press, 1966).

[5] *Ibid.*, (1966), p. 12.

[6] Harry T. Oshima, "Meiji Fiscal Policy and Agricultural Progress," in Lockwood, editor, *The State and Economic Enterprise in Japan*, p. 356.

section. First, what role have the unique demographic features of Japanese history played in producing the Japanese "miracle"? To what extent can the rapid rate of Meiji Japanese growth and industrialization be explained by unusually low rates of labor force (population) expansion compared to contemporary Asia and nineteenth-century western experience? Second, how useful are stage theories for understanding historical development? This is surely an old chestnut. Here, however, we attempt to reproduce quantitatively Rostovian *phases* of historical development from an analytical framework which does not allow changes in parameters or model structure. The results are striking. Third, is the labor surplus framework really a superior, or even an appropriate, interpretation of Meiji Japanese historical experience? Can we develop a neoclassical model which is equally consistent with stable real wages and is capable of producing "turning points," while at the same time producing other predictions which are more consistent with the Japanese historical record? We think so. Fourth, are significant changes in aggregate saving, through the effects of financial institutions or individual behavior, really necessary to generate accelerating rates of growth and industrialization? Can we instead generate "take-offs" and accelerating capital stock and output growth rates under conditions of relative stability in the gross savings rate? Fifth, how useful is the sources-of-growth methodology to understanding the forces of historical growth? If we successfully replicate the sources-of-growth paradox which apparently minimizes the role of capital formation, does that necessarily imply a small role for the savings decision even where technological improvement is fully disembodied? In short, what would have been the quantitative impact of increased savings rates on the historical growth? Sixth, what do we mean by the terms "agricultural backwardness," a "lagging agricultural sector," "concurrent" agricultural growth or "prerequisite" agricultural revolutions?

Insight into these problems can be gained even in the face of intense debate over fact.

Competing Facts and the Japanese Miracle

Since the pioneering research by Ohkawa and the subsequent critique by Nakamura, there have been further efforts to improve on the agricultural output series. The results have recently appeared in Volume IX of the *Estimates of Long Term Economic Statistics of Japan Since 1868* (hereafter LTES). All participants in the debate agree that the LTES estimates are an improvement over the early Ohkawa series. The LTES implied growth rates are lower and the initial agricultural productivity levels are higher. Yet Nakamura's initial critique has hardly been blunted since the LTES estimates are still based on official data of questionable quality and downward bias.[7] There remains considerable uncertainty regarding the magnitude of error.[8]

Because we intend to evaluate the descriptive accuracy of the predictions of a model developed in the next section, it is important that we guard against inadvertently "selecting" estimates which fail to give a completely objective presentation of the range of alternative quantitative interpretations of Japanese economic history. Accordingly, our procedure will be to present the Ohkawa, the LTES, and the Nakamura estimates when primary (or total) output variables are considered. Given the magnitude of the differences between these competing estimates, in some cases, but hardly all, conclusions derived from a comparison of Japanese growth and our model may depend on the choice of series. As a result, based on our detailed examination of the estimation procedures and the debate over measurement, we commit ourselves in advance to the position that the Ohkawa agricultural

[7] The most recent exchange appears in Rosovsky, "Rumbles in the Ricefields," James I. Nakamura, "The Nakamura versus the LTES Estimates of the Growth Rate of Agricultural Production," *Keizai Kenkyu,* XIX (Oct. 1968), 358-61, and Hayami and Yamada, "Agricultural Productivity." In the present paper, we do not have space to review and evaluate the debate. The interested reader may wish to consult Allen C. Kelley, Jeffrey G. Williamson, and Russell J. Cheetham, *Economic Dualism in Theory and History* (Chicago: University of Chicago Press, 1972), ch. v.

[8] Ohkawa and Rosovsky acknowledge the direction of the bias, but not its magnitude. "We are quite prepared to concede that there may have been some underestimation in the early government statistics, but we do not accept either Nakamura's assumptions or the highly inflated output figures which result . . . . Our reading of the evidence (indicates that) official yield figures perhaps contain a slight downward bias (we would suggest in the magnitude of 10-12%), but they are far closer to the mark than the alternative proposed by Nakamura." Ohkawa and Rosovsky also note that the high growth rates are not "impossible" as often implied. Goldsmith's calculations on Tsarist Russia between 1860 and 1913 showed 1.75-2.0 percent per year; post-war growth in the ECAFE region was above 2 percent. K. Ohkawa and Henry Rosovksy, "A Century of Japanese Growth," in Lockwood, editor, *The State and Economic Enterprise in Japan,* ch. ii.

Nakamura is pessimistic regarding a satisfactory resolution of the controversy: ". . . it is not likely that the final word on the controversy over the growth rate of agricultural production will ever be written due to data deficiency." James I. Nakamura, "The Nakamura versus the LTES Estimates," pp. 358-61.

output series is unsatisfactory, and that there are not yet sufficient grounds to ascertain the relative veracity of the Nakamura and LTES estimates. While all three series will be presented below, we shall focus on the Nakamura and LTES versions.

Not only has Nakamura challenged the Ohkawa-LTES output series, but he has also criticized the Rosovsky investment estimates and the Ohkawa figures on capital stock and gainfully employed labor force.[9] Here Nakamura's case is based less on an examination of the quantitative record and more on plausible conjectures and qualifying assumptions. While errors and/or biases may be present in these key input series, their magnitude has not been established with the same degree of confidence as with agricultural production. We shall utilize the Ohkawa and Rosovsky estimates of investment, capital, and the labor force, qualifying the analysis only when alternative estimates would alter our basic comparisons or conclusions.[10]

A PARADIGM FOR PROGRESS

This article takes the view that while dynamic economic systems are complex, it is necessary to begin by formalizing a model structure that incorporates only the most basic elements of the historical growth process. These elements generate model predictions which are then compared with the historical record. If historical experience is successfully reproduced, then at least

[9] Nakamura, *Agricultural Production and the Economic Development of Japan*, pp. 143-49 and 170-72.

[10] Both Rosovsky and Ohkawa have been very careful to present important qualifications to their investment and capital stock estimates. See K. Ohkawa, *The Growth Rate of the Japanese Economy Since 1878* (Tokyo: Kinokuniya Bookstore Co., 1957); K. Ohkawa, M. Sinohara, and M. Umemura, *Estimates of Long Term Economic Statistics of Japan Since 1868* (Tokyo: Toyo Keizai Shinpo Sha, 1966); and Henry Rosovsky, *Capital Formation in Japan 1868-1940* (Glencoe: The Free Press, 1961). Another estimate of capital stock has been compiled in John C. Fei and Gustav Ranis, *Development of the Labor Surplus Economy* (Homewood: Richard D. Irwin, 1964), pp. 125-31 and pp. 146-48. A crucial assumption in their calculation is that the capital stock depreciates at an annual rate of 15 to 20 percent. Their tests relating to the historical analysis of the labor reallocation process uses capital stock estimates based on the 20 percent rate. We feel that the historical record does not justify such high rates of capital consumption. We thus reject the Fei-Ranis estimates and their resulting empirical analysis. A critique of the Fei-Ranis analysis and estimates is provided by E. Reubens, "Capital-Labor Ratios in Theory and in History: Comment," *American Economic Review*, LIV (Dec. 1964), 1052-62; see also Royshin Minami, "The Turning Point in the Japanese Economy," *Quarterly Journal of Economics*, LXXXII (Aug. 1968), 397-98. We have also had the benefit of yet unpublished estimates of capital stock compiled by Colin Clark.

one (although there clearly may be others) useful paradigm of the development process has been uncovered. Historical tests of alternative specifications may, of course, serve to broaden the basis for generalization and for suggesting useful modifications. In sum, our paradigm of the developing nation, while not *the* model of the low-income, growing economy, incorporates several critical features derived from recent Asian history which lead to useful predictions if consistency with the historical record is taken as the basis for judging a model's veracity.

From a wide range of historical observations on the growth and development process, we have chosen to highlight several which characterize the low-income Asian economy. The economy is divided into two sectors, thereby permitting an examination of the relationship of disproportional growth and structural change —industrialization and urbanization—to aggregate economic performance. This dichotomization is justified by the extensive historical literature on industrial revolutions and the critical role assigned to agriculture in early development, together with both the Uzawa two-sector growth models and the development models of Lewis, Fei and Ranis, and Jorgenson.[11] In contrast to the growth-theory literature, which focuses on capital and consumption goods sectors, our framework is in the historical-development tradition where rural-agricultural and urban-industrial activities are highlighted.

Our historical conception of dualism is multi-dimensional. This contrasts with the somewhat narrow conception of economic dualism in the development literature where differing production conditions are examined almost exclusively. The Asian historical record suggests that sectors differ not only in production characteristics, but also in consumer demand behavior and in demographic attributes. For example, tastes and preferences of the urban household tend to be relatively stronger for urban than rural goods at all income levels.[12] Moreover, the urban household will prefer

[11] William Arthur Lewis, "Development with Unlimited Supplies of Labour," *Manchester School of Economics and Social Studies,* XX (May 1954), 139-92; Fei and Ranis, *Development of the Labor Surplus Economy: Theory and Policy* (Homewood, Illinois: Richard D. Irwin, 1964); and D. W. Jorgenson, "The Development of a Dual Economy," *Economic Journal,* LXXI (June 1961), 309-34.

[12] For Japan consult H. Kaneda, "Long-Term Changes in Food Consumption Patterns in Japan, 1878-1964," *Food Research Institute Studies,* VIII, 1 (1968).

somewhat smaller families, a phenomenon widely documented in demographic studies, and which may have a significant impact on demand patterns and structural change.[13] Both of these dualistic features are examined in our model.

There are several ways of incorporating production dualism in formal analysis: (i) sectoral parameter differences (for example, variable bias in technological change, elasticities of substitution), (ii) sectoral differences in production arguments (for example, capital and labor in industry, labor and land in agriculture), (iii) sectoral differences in observed ratio variables. The latter form of dualism is pervasive. In particular, we hypothesize that Asian agriculture is relatively more labor intensive than industry, a feature that has considerable historical support. Of the remaining forms of production dualism, our paradigm emphasizes parameter variation and for two reasons. First, labor-saving biases in industrial technology and labor-using biases in agricultural technology constitute a widely documented feature of the Asian economy.[14] Most dualistic models abstract from this empirically relevant phenomenon. It is captured in the present paper by postulating differing sectoral production parameters. Second, if the long-term historical evolution of agriculture is a point of focus, then it is imperative to include capital explicitly in the agricultural process. Considerable historical evidence is available on the relatively early application of purchased inputs such as fertilizers, insecticides, and machinery.[15] Asian agriculture has become "commercialized" over time and has purchased increasingly large amounts of capital from the industrial sector. A model structure which abstracts from this historical evolution may be inapplicable to most developing Asian economies. In fact, the conventional dualistic model relies heavily on *exogenous* determinants of agri-

13 Allen C. Kelley, "Demand Patterns, Demographic Change and Economic Growth," *Quarterly Journal of Economics*, LXXXIII (Feb. 1969), 110-26.

14 Yujiro Hayami and V. Ruttan, "Factor Prices and Technical Change in Agricultural Development: The United States and Japan, 1880-1960," Staff Paper 69-19, Department of Agricultural Economics, University of Minnesota (July 1969); Tsunehiko Watanabe, "Industrialization, Technological Progress, and Dual Structure," in Lawrence Klein and K. Ohkawa, *Economic Growth, the Japanese Experience Since the Meiji Era* (Homewood: Richard D. Irwin, 1968), ch. iv; and Jeffrey G. Williamson, "Dimensions of Philippine Post-War Economic Progress," *Quarterly Journal of Economics*, LXXXIII (Feb. 1969), 93-109.

15 Nakamura, "Growth of Japanese Agriculture."

cultural labor productivity (for example, *fixed* land endowment and exogenously determined efficiency levels).[16] Since our framework highlights the accumulation of purchased capital inputs in agriculture, agricultural labor productivity is endogenously determined. The resulting model is capable of confronting the critical issue of investment allocation between agriculture and industry.

Finally, our formulation has an explicit spatial dimension. The empirical literature supports the existence of rural-urban differences in consumer behavior, demographic behavior, and production conditions. While neither of these sectors is homogeneous in character, these three aspects of differing sectoral behavior taken together provide the basis for the rural-urban dichotomy. Moreover, one of the most important aspects of economic development is the interregional migration of capital and labor, an area of continued interest to the economic historian. The movement of factors from sectors (regions) of low productivity to those of higher productivity is one of the primary means by which economic progress takes place. Our concern with the spatial dimension contrasts sharply with the Fei-Ranis and Jorgenson approaches which highlight "traditional" production utilizing land and labor alone, and "modern" production employing capital and labor. The traditional enterprise in their models may be either in agriculture or in industry, depending on the extent to which purchased capital inputs are used in production.

Given these broad characteristics of the developing Asian economy, consider briefly the specifications which transform these features into a concrete analytic structure. (i) Production in both sectors is described by a constant elasticity of substitution production function. We assume that the elasticity of substitution in agriculture is equal to or greater than unity, and that in industry it is less than unity. This specification is consistent with con-

16 Our decision to omit land from production is based on several considerations. First, we know of no satisfactory theory of land expansion which commands considerable empirical support. Assuming a fixed supply of land merely guarantees diminishing returns, an hypothesis which could be obtained by assumption. Second, while demand and savings could be affected by differential behavior of property income recipients, again the empirical literature to guide our specification is meagre. See Allen C. Kelley and Jeffrey G. Williamson, "Household Savings Behavior in the Developing Economies: The Indonesian Case," *Economic Development and Cultural Change,* XVI (April 1968), 385-403. A much more detailed defense of our treatment of land is found in Kelley, Williamson and Cheetham, *Economic Dualism in Theory and History,* ch. ii.

siderable empirical evidence and the common observation that industrial technology in the low-income Asian economy is heavily influenced by imported modern techniques. These constraints on substitution elasticities are sufficient to capture the hypothesis that technology possesses a labor-saving bias in industry and a labor-using bias in agriculture. (ii) Technological dualism is further incorporated in the system by assuming that agricultural production is relatively labor intensive. (iii) Consumer demand is described by a Stone-Geary linear expenditure system. This demand specification incorporates the notable attribute of a "subsistence consumption bundle" which must be satisfied before income is allocated to other goods. In our case this subsistence bundle is behaviorally determined, that is, it may change through time according to the "standards" of a given society. Recent historical analyses lend support to the Stone-Geary formulation.[17] (iv) Capital and labor in both sectors are paid their marginal products; neoclassical conditions prevail. The alternative hypothesis of "labor surplus" in agriculture is thus not a feature of our formulation. In fact, this paper will present specific tests on the relative merits of a labor surplus versus a neoclassical interpretation of Japanese economic history. (v) The aggregate savings rate is determined by the source distribution of income, a feature widely supported by historical evidence and the most common hypothesis in growth and development studies. (vi) Population growth is assumed to be more rapid in the rural sector; the variable rate of aggregate population expansion is determined by the rate of urbanization. This is in contrast to the usual formulation where population growth in both sectors is the same—where demographic dualism is absent—and thus total population expansion is exogenously determined.

In summary, the formal static model is composed of sixteen endogenous variables [$Q_i(t)$ = output, $K_i(t)$ = capital, $L_i(t)$ = labor force, $w(t)$ = wage rate, $r(t)$ = return on capital, $P(t)$ = the relative price of industrial goods, $D_{ij}(t)$ = workers' demand, $C_i(t)$ = capitalists' demand, and $I(t)$ = gross investment ($i = 1$ = urban, $i = 2$ = rural; $j = 1$ = industrial output, $j = 2$ = agri-

[17] Richard W. Parks, "Systems of Demand Equations: An Empirical Comparison of Alternative Functional Forms," *Econometrica*, XXXVII (Oct. 1969), 629-50; and Kunio Yoshihara, "Demand Functions: An Application to the Japanese Expenditure Pattern," *Econometrica*, XXXVII (April 1969), 257-74.

cultural output)], and four exogenous variables [$K(t) = \bar{K}$, $L(t) = \bar{L}$, $x(t) = \bar{x}$, and $y(t) = \bar{y}$].

Production

$$Q_i(t) = A_i \left\{ (xK_i(t))^{\frac{\sigma_i - 1}{\sigma_i}} + (yL_i(t))^{\frac{\sigma_i - 1}{\sigma_i}} \right\}^{\frac{\sigma_i}{\sigma_i - 1}} \qquad (i = 1, 2) \quad (1)$$

Worker and Capitalist Commodity Demand

$$\frac{D_{1j}(t)}{L_j(t)} = \frac{\beta_{1j}}{P(t)} [\bar{y}w(t) - \gamma] \qquad (j = 1, 2) \quad (2)$$

$$\frac{D_{2j}(t)}{L_j(t)} = \beta_{2j}\bar{y}w(t) + [1 - \beta_{2j}]\gamma \qquad (j = 1, 2) \quad (3)$$

$$C_1(t) = \frac{\beta_{11}}{P(t)} \{[1 - s]\, r(t)xK - \gamma\} \quad (4)$$

$$C_2(t) = \beta_{12}[1 - s]\, r(t)xK + (1 - \beta_{12})\gamma \quad (5)$$

$$I(t) = \frac{s\bar{x}}{P(t)} [r(t)\bar{K}] \quad (6)$$

Factor Demand

$$w(t) = P(t)\, F_L^1 \quad (7)$$

$$w(t) = F_L^2 \quad (8)$$

$$r(t) = P(t)\, F_K^1 \quad (9)$$

$$r(t) = F_K^2 \quad (10)$$

Employment

$$\bar{K} = K_1(t) + K_2(t) \quad (11)$$

$$\bar{L} = L_1(t) + L_2(t) \quad (12)$$

Market Balancing Equations

$$Q_1(t) = D_{11}(t) + D_{12}(t) + C_1(t) + I(t) \quad (13)$$

$$Q_2(t) = D_{21}(t) + D_{22}(t) + C_2(t) \quad (14)$$

Four equations summarize the dynamic properties of the system (λ_L and λ_K refer to the rate at which physical labor and capital stocks are augmented through technical change):

$$x(t) = x(0)e^{\lambda_K t} \quad (15)$$

$$y(t) = y(0)e^{\lambda_L t} \quad (16)$$

$$\dot{K}(t) = I(t) - \delta K(t), \text{ where } \delta \text{ is a depreciation parameter,} \quad (17)$$

$$\dot{L}(t) = [n_1 u(t) + n_2(1 - u(t))]L(t), \text{ where } u(t) \text{ is the level of urbanization.} \quad (18)$$

The typical approach in considering the long-run dynamic properties of formal models has been to examine the steady-state properties of the system. Steady-state or balanced growth is usually defined as a situation in which the rate of growth of all the relevant magnitudes is constant over time. Surely this conception is irrelevant to the historical experience of low-income growing economies since balanced growth is characterized by constant levels of industrialization and urbanization. The concept of balanced growth may be relevant to the high income economy in late stages of industrialization. Yet, one of the most important interests of the economic historian has always been *non*-proportional growth and structural change in early phases of growth. Furthermore, since this paper focuses on the *growing* economy, the balanced growth features of a system "trapped" in a low-level equilibrium are also ruled out. The growth conception utilized in this paper is the one most appropriate to historical analysis, the movement of the economy through a series of short-run positions from an initial historical "state." In summary, this paper focuses on an economy in motion, a framework at variance with the *modus operandi* of standard growth theory, but fully consistent with the methodology of the *traditional* economic historians.[18]

Modern growth theory has maintained a safe distance from quantitative analysis. The present study departs from this approach. Even though the basic macroeconomic model described above has been subjected to extensive mathematical analysis,[19]

18 We emphasize *traditional* since the *new* economic historian has almost exclusively utilized comparative *static* analysis of formal general equilibrium models.

19 Kelley, Williamson, and Cheetham, *Economic Dualism in Theory and History*, ch. iii.

there is a compelling reason to engage in quantitative analysis. Theorists typically evaluate the *sign* of the variable's response to parameter shifts. Yet the problems and issues of interest to economic historians are largely *quantitative* in nature. While it is instructive to know, for example, that capital accumulation positively affects per capita output expansion, the economic historian surely hopes to evaluate quantitatively the relative importance of different forces influencing growth and structural change. The present study attempts to bridge this gap between abstract growth theory and economic history.

The logical outcome of this argument is that numerical techniques, or simulation analysis, must be utilized to evaluate the long-run trajectories of our economy. The disadvantage of this approach is well known. Since simulations represent special economies, some generality is lost. True, but the historian *is*, after all, interested in special economies at specific phases of development. In our case, the parameters and initial conditions employed below and defended extensively elsewhere (see Appendix A) are taken to be "representative" of contemporary Southeast Asia. This "prototype" has several characteristics at the onset of modern economic growth. First, the economy is primarily rural, with 70 percent of the labor force employed in agriculture. Second, industry is far more capital intensive than agriculture—more than three times as capital intensive. Third, the economy-wide capital-output ratio is approximately two while the ratio in industry exceeds that in agriculture. Fourth, nonagricultural labor productivity is almost twice that of agriculture. Fifth, the share of agricultural output in GNP approaches 60 percent. The largest share of urban output is used to satisfy investment requirements, together with the consumption demand of urban workers and property income recipients. Linkages with the agricultural sector are weak. Sixth, the economy initially generates a gross savings rate of 15 percent, but simultaneously supports a rapid population growth rate of 2.7 percent. Finally, the bias in technical change is labor-saving in industry and labor-using in agriculture.

To return to the question asked above, has much generality been lost by utilizing numerical techniques to analyze our model? Very little. Our objective is to explain successful development from low income levels. The concern is *not* with *all* conceivable growth paths, but only with those which have been historically relevant. This paper is interested in models which are descriptive of the development process. Accordingly, Japanese data drawn from the Meiji period will be used to evaluate the degree to which simulated paths broadly conform with a well-documented historical growth pattern. While neither theory nor history can be confidently used to "predict" the future, when used in *conjunction,* the forecasting capabilities of *both* approaches are increased. Indeed, in our attempt to write economic history backwards, we are in fact attempting to assess the likelihood of predicting the future when the past is the only norm available for appraising our forecasts.

THE OUTLINES OF ECONOMIC DEVELOPMENT AND STRUCTURAL CHANGE

The tendency for both labor and output shares in primary production to decline secularly as growth takes place is well known.[20] These predictions constitute a minimum test for any development model; the simulation model discussed in the previous section certainly passes this test. More significantly, is the *rate* of sectoral shift shown by the simulations consistent with other developing countries at similar levels of development? Even though a period in the simulation is designed to correspond to a calendar year, an examination of the rates of change produced by the simulated economy will establish whether a fifty-period simulation corresponds to the "typical" country's experience over 25, 50, or 100 years. The exercise will also yield a preliminary evaluation of the predictive accuracy of the model. Second, how do these rates of sectoral change compare with those of Meiji Japan? Since Japanese development will be examined extensively in the sections which follow, it is important to appraise the degree to which Japan is a useful historical prototype.

Table 1 compares the per capita GNP growth rate over ten simulation periods with the average decennial growth rates for those countries having sufficient historical documentation. The model's growth of 11.0 percent per simulated "decade" corresponds

[20] S. Kuznets, "Quantitative Aspects of the Economic Growth of Nations: II. Industrial Distribution of National Product and Labor Force," *Economic Development and Cultural Change,* V (July 1957), suppl.; and Hollis B. Chenery, "Patterns of Industrial Growth," *American Economic Review,* L (Sept. 1960), 624-54.

TABLE 1
AVERAGE DECENNIAL GROWTH RATES FOR GROSS NATIONAL PRODUCT PER CAPITA[a]

Sample	*Period*	*Rate (%) per Decade (Period)*
1. Simulation	1-50	11.0
2. Argentina, Brazil, Chile[b]	1925/1929-1950/1954	11.9
3. Philippines[c]	1955-1965	14.0
4. Kuznets' Sample[d] "Less Economically Developed Areas"	1885-1950	10.4
5. Japan[e]		
Ohkawa	1883/1887-1908/1912	31.4
LTES	1883/1887-1908/1912	25.4
Nakamura	1883/1887-1908/1912	21.9

[a] Kuznets average decennial growth rates represent the average of the individual decade rates for the intervals indicated. For each decade the initial period is used as the denominator in the calculation. Since our interest is in comparisons between entries, the conclusions are not sensitive to the particular computational procedure employed.

[b] The Latin American data represent the arithmetic average of the decadal ratio for the three countries; S. Kuznets, *Six Lectures on Economic Growth* (Glencoe: The Free Press, 1959), p. 22.

[c] The Philippine growth rates are computed from data found in United Nations, *Yearbook of National Income Accounts, 1967* (New York: United Nations, 1968); United Nations, *Economic Survey of Asia and the Far East* (New York: United Nations, 1968).

[d] Ireland and Eire, Spain, Hungary, and Italy are identified by Kuznets as being "less economically developed areas."

[e] In combining the LTES and Nakamura (medium yield) primary output series with the Ohkawa non-primary output series, we assumed that the primary output series grew at their own respective rates and that each series was equal in level to the Ohkawa figure in 1900.

very closely to the long-term decennial growth performance for Argentina-Brazil-Chile (11.9 percent) and Kuznets' sample of "less economically developed areas" (10.4 percent). In contrast, Japanese growth averaged an astounding 21.9-31.4 percent per decade. Japan is clearly unusual in terms of the performance of either our model or the historical record of the low-income countries. Taking the expansion of GNP per capita as the norm, we may conclude that the simulation *period* appears to coincide very well with the *yearly* change occurring in the low-income countries; Japan collapses this progress into about *one-half year* of experience.[21]

[21] This theme is also developed by Nakamura. "The Japanese experience, however, differed from that of the Western economies in many important respects, at least in *degree* where not in kind. Growth was assured within twenty years after the Meiji Restoration. . . . Her development from a feudal to an industrial economy of the

In making detailed comparisons of the simulation model's performance with observed trends in sectoral growth rates and shares, the procedure will be to compare our rural-agriculture sector with the "primary" sector designation in the quantitative literature. We know of no satisfactory way of allocating the activities of tertiary production between the primary and secondary sectors. The implication is that comparisons of *levels* of output and employment shares found in the empirical literature with those in the simulated economy are not particularly meaningful yet growth rates are more likely to be so.

Since it is well established that rates of sectoral change vary with the level of per capita income, initial per capita output assumed in the simulation must also be identified.[22] The basic parameter values used in the simulations are drawn from Southeast Asia, although in most dimensions they have much wider applicability. Accordingly, the initial period's per capita output level is taken as $150 (1960 dollars), the average output per capita prevailing in Southeast Asia, 1950-1963.[23] Since GNP per capita increases by 68 percent over fifty periods in the simulation model, it seems appropriate to examine the rates of structural change in economies whose income levels per capita span the range $150-$250.

Table 2 compares the rate at which the dualistic model is shifting out of primary production with those derived from time series studies and from a cross section of countries. The model produces shifts out of agricultural production at an average rate of —.48 percent per period. This compares very closely with the cross section studies of both Chenery-Taylor and Kuznets. For their respective samples over similar variations in per capita output, they show primary production shares declining at rates of —.44 and —.46 percent, respectively. Of equal significance, for a wide range of presently developed areas, Kuznets shows historical rates of —.52 percent. In contrast, Japan attained rates of structural change between two and three times those found in both the "typical" case and the model forecasts.

1930's was crowded into a *shorter span of years.*" (Emphasis ours.) Nakamura, *Agricultural Production and the Economic Development of Japan*, p. 21.

22 Hollis B. Chenery and Lance Taylor, "Development Patterns: Among Countries and Over Time," *The Review of Economics and Statistics*, L (Nov. 1968), 393-403.

23 The countries included in the average are Burma, Cambodia, Thailand, Taiwan, South Korea, Philippines, Malaya, and Japan. *Ibid.*, p. 414.

TABLE 2
RATES OF CHANGE IN THE PRIMARY-OUTPUT SHARE

Country or Sample	*Period or Income Range*	*Rate of Decline per year (period)*[a] (%)
Simulation	1-50	− .48
Chenery[b]	\$150-\$250	− .44
Kuznets' Cross Section Sample[c]	\$150-\$250	− .46
Kuznets' Time Series[d]	1850-1895	− .52
Japan[e]		
Ohkawa	1883/1887-1908/1912	−1.06
LTES	1883/1887-1908/1912	−1.31
Nakamura	1883/1887-1908/1912	−1.49

[a] The computational formula, where $P(t)$ = primary output share at initial year (period) t, is $\{[(P(t+n) - P(t))/P(t)]/n\}100$ where n = number of years in interval. When considering cross section data, n = 50, corresponding to the assumed fifty years required for a "typical" developing country to increase its per capita income level from \$150-\$250.

[b] This represents the case of large country patterns typical of most countries under consideration. Of the Southeast Asian countries, these regressions include Burma, Thailand, Korea, Philippines, and Japan. H. B. Chenery and L. J. Taylor, "Development Patterns: Among Countries and Over Time," *Review of Economics and Statistics,* L (Nov. 1968), 394.

[c] The Kuznets' data correspond to two income groupings, \$100-\$199 and \$200-\$349. The estimates for \$150-\$250 assume that Kuznets' figures apply to the mean of the income groupings and that between these means the share changes linearly. S. Kuznets, *Modern Economic Growth* (New Haven: Yale University Press, 1966), p. 402.

[d] The sample includes all countries in Kuznets' table for which data were available for the period before 1900. These countries are the United Kingdom, France, Germany, Denmark, Norway, Sweden, Italy, United States, and Australia. Japan is excluded and treated as a separate observation. The periods and initial and concluding levels represent an unweighted average of the nine countries included in the sample.

[e] See note e, Table 1.

The rate of decline in agriculture's labor force share tends to vary positively with the level of per capita income.[24] Because of this non-linear trend, we present in Table 3 the rate predicted by the model in both the first fifty periods (—.32 percent per period) and the subsequent one-half century of per capita output expansion (—.56 percent). Kuznets' cross section study reveals a similar pattern where the rate of decline increases from —.27 to —.40 percent over comparable levels and ranges of development. For relatively high levels of per capita income, Kuznets estimates the rate to be around —.68 percent per year. We infer that

[24] *Ibid.*, and S. Kuznets, *Modern Economic Growth* (New Haven: Yale University Press, 1966).

TABLE 3
RATES OF STRUCTURAL CHANGE IN THE PRIMARY LABOR FORCE SHARE

Country or Sample	*Period or Income Range*	*Level (%)*		*Rate of Decline Per Year (period)*[a] *(%)*
		Initial	*Concluding*	
Simulation	1-50 ($150-$250)	70.1	58.8	−.32
	51-100 ($250-$500)	58.7	42.2	−.56
Kuznets' Cross	$150-$250	55.7	48.1	−.27
Section[c]	$250-$500	48.1	36.5	−.40
Kuznets' Time Series[d]	1860-1897	44.8	33.5	−.68
Japan[e]	1872-1925	85.0	52.0	−.73

[a] For the computational formula, see Table 2.

[b] From period 51-100, GNP per capita in the simulation model increased by 96 percent which corresponds to a variation of cross section performance and the range $250-$500.

[c] For a discussion of the computational procedure, see note c, Table 2. S. Kuznets, *Six Lectures on Economic Growth* (Glencoe: The Free Press, 1959), p. 45.

[d] The eight countries included in Kuznets' sample are United Kingdom, France, Belgium, Switzerland, Norway, Sweden, Italy, and the United States. S. Kuznets, *Modern Economic Growth* (New Haven: Yale University Press, 1966), pp. 106-108.

[e] The individual rates of decline for the periods 1880-1890, 1890-1900, 1900-1910 are −.75, −.81 and −.99 percent, respectively. K. Ohkawa (in association with M. Shinohara, M. Umemura, M. Ito and T. Nota), *The Growth Rate of the Japanese Economy Since 1878* (Tokyo: Kiholuniya Bookstore Co., 1957), p. 145.

rates of decline exceeding −.50 percent correspond to relatively advanced levels of development. In terms of rates of change, then, Japan's experience must again be considered unusual when compared with the empirical record of most countries for which data are available.

TEMPORAL COMPARISONS OF MEIJI JAPAN AND THE SIMULATED SOUTHEAST ASIAN ECONOMY

Economic historians have attempted to generalize from the Meiji era to contemporary Asian experience. While this paper is equally interested in generalizing, it applies a somewhat novel methodology. We attempt first to understand the present; we then move backwards into history. The object is the same. To what extent can the lessons of Japanese economic history be applied to contemporary Southeast Asia? As emphasized by Leontief almost a decade ago, the advantage of writing history backwards is that contemporary data are more abundant. Parameter differences between Meiji Japan and present day Southeast Asia are to be expected. The issue, however, is whether the economies are so different that attempts at rewriting Japanese history by using a contemporary data base will fail. If we do fail, then the lessons from Meiji Japan are far more limited than is conventionally thought. Thus far we have only indicated success in rewriting the broad quantitative history of the developing economies as a group.

One of the most striking differences between our modelled economy and Meiji Japan is in labor force growth. The annual rate of population growth was only .9 percent in Meiji Japan while in contemporary Southeast Asia and thus in the simulation the rate is 2.7. Given the exceptionally high rate of economic progress there is a *prima facie* case that the Japanese "miracle" may in large part be explained by the relatively low population pressure. How can this divergence in Japanese conditions be taken into account? We could resimulate the model with a new population parameter. But methodologically this would be rewriting Japanese history, not examining Japanese experience in light of a contemporary setting. Moreover, and equally important, such a change would also argue for altering *all* the parameters and initial conditions where evidence indicates even slight divergence; focusing on one parameter would be somewhat arbitrary. Given these considerations, we will instead search for a simple, but meaningful, adjustment which will account for the divergence of population growth on our model predictions. We shall show below that a period-year correspondence between Japanese economic history and the model does not seem at all appropriate, and that a simple transformation of this relationship will quite adequately capture the impact of the demographic differences between the two systems.

The Rate of Japanese Economic Growth

The rapid, sustained and accelerating character of economic growth has been cited by many as possibly the most distinguishing characteristic of Japanese development.[25] What we have established, however, is the *magnitude* by which the rate of Japanese

[25] K. Ohkawa and Henry Rosovsky, "The Role of Agriculture in Modern Japanese Economic Development," *Economic Development and Cultural Change,* II (Oct. 1960), 43.

progress appeared to surpass that of the "typical" country undergoing growth at roughly similar levels of development. Appealing both to cross section and time series data drawn from a wide range of currently developed and underdeveloped nations, our comparisons suggest that the rate of Japanese progress was about *twice* that experienced elsewhere. In contrast, the average rate of growth and structural change for a period in the simulation model is remarkably similar to that found in the historical and cross-section record.

These observations suggest that we compare *one* year of Japanese experience with *two* periods in the simulated economy. The interrelationships between key variables in our model—commodity prices, capital-labor ratios, factor prices, population and output redistribution—are, of course, completely independent of the time dimensionality. Thus, the comparison of one year's experience in Japanese economic history with two periods of the simulated economy in no way interferes with a meaningful evaluation of our model's ability to reproduce economic history.

The Growth of Population and the Demographic Revolution

As noted above, a primary argument for altering the basic dimensions between a period in the model and a year of Japanese growth can be found in labor force growth experience. The current "population explosion" is well known. Perhaps the magnitude of the demographic revolution is less well appreciated. Much of contemporary Southeast Asia has population growth rates three times those of Meiji Japan: Japanese labor force growth rates (n) prior to 1915 are fairly stable at 0.9 percent per annum while we assume an initial rate of 2.7 percent in the simulation. Moreover, unlike many of the other parameters for Japan, demographic experience is documented by extensive empirical evidence.[26] Finally, we have shown elsewhere through comparative static and sensitivity analysis that the impact of population growth on our economy has been found to be both important and pervasive.[27]

[26] Ohkawa, *The Growth Rate of the Japanese Economy Since 1878;* and Irene Taeuber, *The Population of Japan* (Princeton: Princeton University Press, 1958).

[27] Kelley, Williamson, and Cheetham, "Biased Technological Progress and Labor Force Growth in a Dualistic Economy," *Quarterly Journal of Economics* (forthcoming); and Kelley, Williamson and Cheetham, *Economic Dualism in Theory and History,* ch. vi.

A simple means of qualifying the analysis is to alter the dimensionality of the period-year correspondence in the direction already suggested: equating one year of Meiji Japanese experience to two years in the simulation. The rationale for this procedure can be illustrated by considering the impact of *n* on two key measures of development: the rate of per capita output growth and the rate of labor force redistribution ("urbanization"). Suppose, for example, that the natural rate of *rural* population growth has been reduced from three to one percent per annum. (This is consistent with reducing aggregate population growth from .027 to .009 while at the same time maintaining the dualistic demographic properties of the model.)[28] What would be the resulting impact on per capita output growth and the level of urbanization?[29] In period 50 the level of urbanization would increase from 41.2 percent (using $n_2 = .03$) to 51.5 percent (using $n_2 = .01$). Since the initial level of urbanization is .30, then the downward adjustment of the population parameter to conform with Japanese conditions *doubles* the rate of population redistribution in the simulation model.

A similar impact on the rate of per capita output growth (g) is found from a 100 percent reduction of n_2. By altering n_2 alone, per capita output growth increases from 11.7 to around 16.1 percent per decade; *g* increases further to 17.9 percent when both sectoral population parameters are altered. We conclude that a simple way of adjusting the simulation results to conform to Japanese experience is to assume that one year of Japanese progress corresponds to roughly two periods of the simulated economy. Indeed, *these results are consistent with the hypothesis that the unusual rapidity of Japanese development was the result of low population growth rates.*

Initial Conditions: The Simulation Model and Japan

The period of Japanese economic history examined is roughly 1882/1887-1908/1913. Several factors point to these years as being the appropriate span of historical evidence with which to confront

[28] Note that $n = n_1u + n_2(1 - u)$. Taking $n = .009$, $u = .3$, and the dualistic assumption that $n_2 > n_1$, and in particular, $n_2/n_1 = 1.5$, the resulting values of n_1 and n_2 are .0067 and .01, respectively.

[29] While this experiment could be carried out by resimulating the model, a simpler method which yields roughly equivalent results involves the use of structural elasticities already estimated for the Southeast Asian prototype. See Kelley, Williamson, and Cheetham, *Economic Dualism in Theory and History*, chs. v and vi.

the model's predictions. First, in terms of the sectoral distribution of output and labor force, the two key initial conditions of economic development, the year 1885 corresponds most closely with the sectoral patterns of the simulation model. In the mid 1880's, 54 percent of Japanese output was produced in the primary sector while utilizing approximately 71-79 percent of the total labor force.[30] Similar initial conditions for the simulation model are 57 and 70 percent, respectively. Second, the model describes a development phase in which economic progress is both continuous and sustained. Kuznets has termed this phase as Modern Economic Growth.[31] Rosovsky has argued persuasively that Japanese Modern Economic Growth begins about 1885.[32] This year ends a transition in which the joint priorities of industrialization and growth were elevated to national objectives and when Modern Economic Growth actually commenced. The Matsukata Deflation in 1885 marks a period when currency reform, banking development, and government political and economic structure were all consolidated toward the ends of modern economic growth.

Third, World War I represented an unusually strong exogenous shock to the pace and structure of Japanese economic development. Thus, 1915 is a logical terminal point for our inquiry.[33]

[30] Ohkawa, *The Growth Rate of the Japanese Economy Since 1878*, pp. 26-7. Nakamura argues that the Ohkawa labor force series overstate the percentage of the work force in the agricultural sector. (See Nakamura, *Agricultural Production*, p. 147.) For 1885 two separate estimates by Nakamura yield 71.1 and 72.1 percent. For the same period, the Ohkawa estimates yield 79.2 percent.

[31] In Kuznets' framework, MEG is characterized by four conditions: (1) the application of modern scientific thought and technology to industry, (2) a sustained and rapid increase in real product per capita, usually accompanied by high rates of population growth, (3) rapid rates of transformation of the industrial structure (changing sectoral output, labor force and entrepreneurial distributions), and (4) the emergence of or expansion in international contacts. S. Kuznets, *Six Lectures on Economic Growth* (Glencoe: The Free Press, 1959), Lecture 1.

[32] While marked economic, political, and social change occurred in Japan beginning with the Meiji Restoration of 1868, these events established the necessary, but not the sufficient conditions, for MEG. Namely, the Restoration is a period when MEG becomes a national *objective*, not a revealed occurrence as identified by Kuznets' empirically verifiable criteria. Rosovsky thus characterizes the period 1868-1885 as Japan's "transition" to modern economic growth. During this period the banking system was developed, fiscal and monetary reform undertaken, social barriers to progress attenuated, political power in the central government consolidated, and so forth. See Henry Rosovsky, "Japan's Transition to Modern Economic Growth, 1868-1885," in Henry Rosovsky, editor, *Industrialization in Two Systems: Essays in Honor of Alexander Gerschenkron* (New York: Wiley, 1966), pp. 91-139. See also Ohkawa and Rosovsky, "A Century of Japanese Growth," pp. 47-66.

[33] Ohkawa and Rosovsky divide their examinations of long term change in the Japanese economy into three periods: period I, from the Meiji Restoration to World War I; period II, from World War I to World War II; and period III, from World

While 1882/1887-1908/1913 constitutes the main period in which Japanese economic history is compared with the predictions of 50 simulation periods, a *precise* correspondence of 1885 with period 1 in the simulation is not implied. Furthermore, while World War I marks the terminal point in the analysis, on several occasions, where trends in the Japanese time series are not clear by examining only twenty-five years of data, the comparisons will be extended.

In Table 4 a comparison between Japanese and the simulated economy's rates of sectoral output and labor force redistribution is presented. The close correspondence in these two key measures of structural change (using the Ohkawa series) confirms our choice of the period-year adjustment discussed above.[34]

TABLE 4
PERCENT OF RURAL LABOR AND OUTPUT IN THE SIMULATED ECONOMY AND JAPAN

Period	*(Year)*	*Labor Force*		*Output*			
		Simulation	*Japan*[a]	*Simulation*	*Japan*[b]		
					Ohkawa	*LTES*	*Nakamura*
1	(1885)	100.0	100.0	100.0	100.0	100.0	100.0
10	(1890)	98.9	96.1	96.5	99.1	94.7	93.5
20	(1895)	96.5	92.3	91.8	94.1	83.1	83.1
30	(1900)	92.9	88.3	86.3	87.4	74.5	72.6
40	(1905)	88.7	84.0	81.1	83.8	74.2	71.1
50	(1910)	84.0	79.5	75.8	77.8	67.1	62.6

[a] The labor force shares are from Ohkawa, *The Growth Rate of the Japanese Economy*, p. 27.
[b] See note e, Table 1.

JAPANESE GROWTH AND THE SIMULATED ECONOMY COMPARED IN DETAIL

The detailed comparison of the simulated economy with the Japanese historical record focuses on seven measures of perfor-

War II to the present. Justifying the demarcation at World War I, they note, "In spite of the sustained character of growth in Japan, the relative position of major sectors in the economy changed considerably. . . . World War I marked a distinct structural change especially pronounced in the relations between agriculture and industry." Ohkawa and Rosovsky, "The Role of Agriculture," p. 43.

In a later study, these authors consider the period 1886-1905 as the initial phase of modern economic growth. From 1906-1930 a different economic structure is created which sets the pattern for the second phase of modern economic growth. Ohkawa and Rosovsky, "A Century of Japanese Economic Growth," ch. ii.

34 It should be noted that had we used the recently revised non-primary LTES series (not yet available), then the correspondence would have been much closer with the LTES and Nakamura figures.

mance: capital-labor ratios, the rate of capital accumulation, savings rates, factor shares, capital-output ratios, labor productivity, and real wage behavior. In this section we shall only present the numerical comparisons and postpone a detailed discussion of their analytical and historical significance until a later section. What is the relative correspondence of the simulated economy and Meiji Japan? Have we been successful in writing Japanese history backwards?

Some general remarks on the relevant criteria for evaluating our success in reproducing Japanese economic history might be helpful before examining each variable in detail. Our quantitative model belongs to a general class of simulation models which pose special difficulties in the evaluation of performance. In contrast with conventional simultaneous equation systems, the usual R^2 and "t" statistics simply cannot be applied. Goodness of fit must be inferred in other ways. Several methods are available including Theil's information loss statistic and the NBER conformity and diffusion indices. Each of these methods must deal with the temporal dimension of prediction (for example, month, year or decade), the unit of prediction (for example, turning points or rates of change), and the relative weights attached to each variable in evaluating the overall performance of the model. Clearly, a "test" is sensitive to the choice of temporal dimension, unit of prediction, and relative weights; these can only be selected (often somewhat arbitrarily) with reference to the specific problem at hand.

The focus of this essay is the *changing structure* of an economy through time, rather than with the levels of prices, outputs or inputs at any point in time. Indeed, given some disparity between the initial conditions which prevailed in Meiji Japan and those assumed in the simulation, comparisons of levels of performance would be inappropriate and misleading. Rather, we shall focus on the direction of change in economic variables and the variability in those rates of change over time. Furthermore, our interest is in long-term performance rather than annual variations and, as a result, only decadal changes in the variables are considered.

While formal tests are not presented in the discussion of each variable below, it would be useful at this point to summarize our findings in terms of a simple index of conformity. In particular, the signs of the first and second derivatives of comparable series produced by our model and drawn from Meiji Japan are compared. The percentage of the total comparisons in which the series directly conform are then computed. The overall conformity of our model to Japanese historical experience appears to be high; the model predicts accurately 75 to 81 percent of the time, depending on whether the official or the Nakamura agricultural output series is utilized. Considering only those results which include the Nakamura series, the first derivatives conform about 90 percent of the time, while the second derivatives conform seven times out of ten. Yet there is considerable variation by series. On *a priori* grounds, the capital-labor ratio should receive special weight. After all it is the key variable explaining economic performance over time and furthermore the historical data on this variable are less subject to data controversy. The model predicts this variable's behavior with an especially high level of accuracy: 100 percent first derivative, 88.9 percent second derivative, and 95.2 percent overall.

The second derivative comparisons are clearly sensitive to short-run variations in Japanese development, for example, the Sino-Japanese War, depression, and natural disasters. Since the model focuses on long-term trends, it would have been more appropriate to smooth the Japanese figures. Our use of the unsmoothed data presumably implies a lower bound on our indices of conformity between the two models. Finally, the discussion which follows will indicate our model predicts turning points in the Japanese data very well. An interesting case in point is the brief period of capital shallowing in agriculture early in the Meiji period which the model also predicts. Whether examining turning points, trends or rates of trend changes, the model's overall conformity with Japanese historical experience appears to us to be high.

The Capital-Labor Ratio

Since the behavior of the capital-labor ratio (k) is critical in interpreting growth performance, we begin with an examination of this variable's trajectory. The upper panel of Table 5 (columns (1)-(3)) provides the basis for the following summary of the simulated paths of k_1: (i) k_1 increases throughout at an increasing rate; (ii) k_2 decreases initially and then increases at an increasing rate; (iii) k_1 exceeds k_2 throughout; (iv) the growth in k_1 exceeds that of k_2 although the trend reverses at higher levels of development; (v) k increases throughout at an increasing rate. The similarity between these predictions and the Japanese historical record is striking. Of particular interest is the early period of capital shallowing in Japanese agriculture.[35] The simulation model has been able to capture even this phase of Meiji agricultural development.

TABLE 5
ANNUAL GROWTH OF k: THE SIMULATED ECONOMY AND JAPAN

	Simulation (%)			Japan (%)			Year
	k (1)	k_1 (2)	k_2 (3)	k (4)	k_1 (5)	k_2 (6)	
0-10	.6	.9	− .1	.6	1.0	− .3	1885-1890
10-20	1.1	1.1	.5	1.6	2.3	.2	1890-1895
20-30	1.7	1.3	1.1	2.5	3.2	.9	1895-1900
30-40	1.8	1.4	1.5	2.2	1.8	2.0	1900-1905
40-50	2.1	1.6	2.0	4.3	4.3	2.3	1905-1910
	Average of Growth Rates over 50 Periods (25 years)						
	1.5	1.3	1.0	2.2	2.5	1.0	

Note: The Japanese data for 1885-1890 correspond to 1882/1887-1888/1892. Subsequent years are similarly aligned. The capital stock figures, representing net capital stock (1934-1936 prices) less residential buildings, are found in K. Ohkawa, M. Shinohara, and M. Umemura, *Estimates of Long Term Economic Statistics of Japan Since 1868* (Tokyo: Toya Keizai Shinpo Sha, 1966), Vol. 3, Tables 2, 5. The labor force figures are gainfully employed population, Ohkawa, *The Growth Rate of the Japanese Economy,* p. 27.

In addition to the trend comparisons, note also the generally close correspondence of *levels* of k growth. While the average growth in Japanese k is slightly less (1.5 versus 2.2 percent), the differences are small using the total variation of each series as the norm. This is in contrast to the Japanese experience of capital deepening in industry where both the level (2.5 percent) and its size relative to agriculture (2.5 versus 1.0 percent) is significantly greater than the simulated economy.[36] On the other hand, the average growth of k_2 is the same in the two economies. While

[35] Fei and Ranis have found significant capital shallowing over the entire period 1888-1916 in the *industrial* sector. See John C. H. Fei and Gustav Ranis, "Innovation, Capital Accumulation and Economic Development," *American Economic Review,* LIII (June 1963); and Fei and Ranis, *Development of the Labor Surplus Economy.* For reasons discussed in the ensuing paragraphs, we cannot accept their estimates and conclusions.

[36] While the possible understatement of agricultural capital stocks and investment due to the exclusion of land improvement must qualify this observation, the conclusion is not likely to be overturned. On measurement biases, see Nakamura, *Agricultural Production and the Economic Development of Japan, 1873-1922,* p. 172; K. Ohkawa, book review, *Economic Development and Cultural Change,* XII (Oct. 1963), 100; and Rosovsky, *Capital Formation in Japan 1868-1940,* p. 6.

capital deepening proceeded at higher rates in Japanese non-primary production, it appears that in all other respects—aggregate and sectoral levels, trends, and rates of trend changes—the behavior of Japanese capital-labor ratios is remarkably similar to those revealed in the simulation.

Capital Accumulation, Savings, Factor Shares, and the Capital-Output Ratio

The role of capital accumulation in our model depends on the joint behavior of the capital share and the capital-output ratio. Since the capital share constitutes the only force altering our economy-wide savings ratio, it is convenient to analyze Japanese rates of capital accumulation within the same framework.

A comparison of the rates of capital accumulation in the simulated economy and Japan is presented in Table 6. The simulated model predicts: (i) total and sectoral rates of capital accumulation increase at an increasing rate; (ii) the primary sector has accumulation rates substantially less than the non-primary sector; and (iii) the relative pace of the primary sector's capital accumulation increases over time. As with the capital-labor ratio, the trends in Japanese capital accumulation are the same as those forecasted by the model. On the other hand, the magnitude of the growth rates differs considerably. While the overall rate of accumulation is very similar in the two economies (3.4 versus 3.0 percent), the rates are considerably higher in Japanese industry and much lower in Japanese agriculture.

TABLE 6
ANNUAL GROWTH RATE OF k: THE SIMULATED ECONOMY AND JAPAN

Period	*Simulation (%)*			*Japan (%)*[a]			*Years*
	Primary	*Non-Primary*	*Total*	*Primary*	*Non-Primary*	*Total*	
1-10	1.6	2.9	2.3	.2	5.1	1.9	1885-1890
10-20	2.2	3.6	3.1	.4	5.6	2.7	1890-1895
20-30	2.7	4.0	3.5	.4	6.2	3.2	1895-1900
30-40	3.1	4.2	3.8	.6	4.6	2.8	1900-1905
40-50	3.4	4.3	4.1	1.2	6.7	4.4	1905-1910
Average	2.6	3.8	3.4	.6	5.6	3.0	

[a] The Japanese capital stock series, representing net capital (1934-1936 prices) less residential structures, are from Ohkawa, *Estimates of Long Term Economic Statistics*, Vol. 3, Tables 2, 5.

TABLE 7
NET AND GROSS SAVINGS RATES: THE SIMULATED ECONOMY AND JAPAN

Period	*Simulation (%)*		*Japan (%)*[a]		*Years*
	Net (NDCF/ NNP)	*Gross (GDCF/ GNP)*	*Net (NDCF/ NNP)*	*Gross (GDCF/ GDP)*	
1-10	6.6	15.1	8.0	12.3	1887-1896
10-20	7.2	15.3	8.0	12.4	1892-1901
20-30	7.8	15.5	7.2	11.9	1897-1906
30-40	8.2	15.8	8.8	13.6	1902-1911
40-50	8.5	16.1	8.8	13.8	1907-1916

[a] The savings figures include government investment in military durables. H. Rosovsky, *Capital Formation in Japan 1868-1940* (Glencoe: The Free Press, 1961), p. 9.

The economy-wide net and gross savings rates for the two economies are presented in Table 7. Again, the modelled economy and Japan generate comparable trends. Both the net and the gross savings rates increase very slowly through time. The model and Japan both experienced accelerating economic progress *without* a major increase in savings rates. While there may have been a substantial upward shift in Japanese savings subsequent to the period considered here, the stability of this variable is clearly a notable feature of the early phase of Japanese modern economic growth.

The gradual increase in the savings rate is explained in our model by a change in factor shares. Unfortunately, as yet there is very little evidence on capital share trends in Meiji Japan.[37] While not specifically explaining the rising trend in savings during the early stages of Japanese growth, Ohkawa and Rosovsky conclude that the expansion subsequent to 1905 was due to a movement away from traditional production and toward more capital-intensive techniques in the modern sector.[38] In the early period they emphasize the rate of agricultural surplus creation which, through government taxes (primarily the land tax), was channeled into non-primary production.[39] The economy-wide savings rate thus depended upon a rapidly growing agricultural surplus.

37 From 1920-1942 Ohkawa finds a decrease in both the economy-wide and in the industrial sector's labor share. See K. Ohkawa, "Changes in National Income Distribution by Factor Share in Japan," in J. Marchal and B. Ducros, editors, *The Distribution of National Income* (New York: St. Martin's Press, 1968), pp. 177-96.

38 Ohkawa and Rosovsky, "A Century of Japanese Economic Growth," pp. 77-79.

39 Rosovsky, *Capital Formation in Japan 1868-1940;* Rosovsky, "Rumbles in the

Nakamura's interpretation of aggregate savings behavior is quite different.[40] He places far greater emphasis on the distribution of income as a determinant of aggregate savings. For Nakamura, savings growth depended primarily on capturing an increasing share of the existing surplus. This contrasts with the Ohkawa-Rosovsky interpretation where increased savings is based mainly on obtaining a share of a rapidly expanding surplus product.[41]

According to Nakamura, the Restoration transferred income from the high-consuming ruling class (including the samurai and daimyo) to a new group of lower-consuming landowners. Decreases in the Meiji land tax coupled with the erosion of the tax burden through inflation distributed income to the relatively higher savers. The landowners not only saved, but "the rural landlord-merchant played a major role in early Meiji financing by establishing and operating banking institutions and industrial and commercial enterprises."[42] In sum, the savings mechanism which Nakamura finds supported by qualitative evidence is consistent not only with our theoretical framework and with Japanese savings trends, but also with the hypothesis that the labor share in Japan was declining over time. Even though the Tokugawa ruling class can be considered as early capitalists, the income distribution relevant to the present discussion took place *after* the Meiji land reforms. In this case the capitalists were the landowners to whom a lower tax burden and inflation conveyed substantial windfall gains. If this is the case—and we find this is a plausible interpretation of Meiji Japan—then an overall decline in the labor share, causing a gradual rise in the economy-wide savings rate, appears consistent with the historical record.

The trend toward economizing capital in production, both economy-wide and by sector, is a feature of the simulation model critically contributing to the gradually rising rates of capital accumulation. Indeed, Table 9 shows that much more than half of the increase in the rate of capital stock growth can be attributed to the decline in the capital-output ratio. Similar trends in the capital-

Ricefields," p. 360; Ohkawa and Rosovsky, "The Role of Agriculture in Modern Japanese Economic Development."

40 Nakamura, *Agricultural Production and the Economic Development of Japan, 1873-1922*, p. 151 and pp. 155-69.

41 Rosovsky, "Rumbles in the Ricefields," p. 360.

42 Nakamura, *Agricultural Production and the Economic Development of Japan, 1873-1922*, p. 167.

output ratio are found for Japan. Whether we use the LTES or the Nakamura output series, Table 8 shows an economizing on capital, although the Nakamura figures show this trend to be somewhat weaker; indeed, using LTES figures, the capital-output ratio in agriculture declines from 2.4 to 2.0 in a period of only fifteen years.

Table 9 compares the percentage change of the accumulation rate, the capital-output ratio, and savings rate for the model and for Japan, using the Ohkawa, the LTES and the Nakamura output estimates. The rate of capital accumulation increases by about 45 percent in both the simulated economy and in Japan. Previous analysis of the simulation has shown that over one-half of this increase in $\dot{K}/K$ is explained by the 11 percent decrease in the capital-output ratio; the remainder is attributed to an increased aggregate savings rate. Since the aggregate savings rate increased less markedly in Japan than in the simulation, then the decrease in the capital-output ratio must have assumed an even greater role in the Japanese case. This is supported by the Ohkawa, LTES and the Nakamura estimates.

With few exceptions the trends in Japanese rates of capital accumulation, aggregate savings, and capital-output ratios are very similar to those of the simulated economy. We now turn to an examination of sectoral labor production.

Labor Productivity

Economic development is normally characterized as a process through which labor productivity increases over sustained periods of time. This is revealed in the simulation results presented in Table 10 (columns 1, 5, 7 and 11) where several trends may be noted: (i) sectoral and total labor productivity increase monotonically over time; (ii) the labor productivity increases in secondary production exceed those in the primary sector in early phases of growth while this trend is reversed in later phases of growth; (iii) absolute labor productivity is always greater in the non-primary sector (not shown here).

A comparison of these simulated paths with Japanese economic history is complicated by the controversy over the LTES and Nakamura agricultural output estimates. Consider first those compiled by Ohkawa. Column 2 clearly reveals the most prominent feature of the "Japanese model." Labor productivity growth in Japanese agriculture is nothing short of phenomenal, given the

TABLE 8

CAPITAL-OUTPUT RATIOS FOR THE SIMULATED ECONOMY AND JAPAN[a]

Period	Simulation[b]			Japan									Year
				Ohkawa Series			LTES Series		Nakamura Series				
	Total	Sector 1	Sector 2	Total	Sector 1	Sector 2	Total	Sector 2	Total	Sector 2			
1	1.9	2.5	1.4	2.5	1.9	3.0	2.2	2.4	2.1	2.2			1885
10	1.8	2.4	1.3	2.2	1.9	2.5	2.1	2.2	2.1	2.1			1890
20	1.7	2.3	1.2	2.1	1.9	2.4	2.1	2.2	2.0	2.1			1895
30	1.7	2.2	1.1	1.9	1.9	2.0	1.9	2.0	1.9	2.0			1900
40	1.7	2.1	1.1	2.1	2.1	2.0	2.0	1.9	2.1	2.0			1905
50	1.7	2.1	1.1	2.1	2.2	1.8	2.1	1.8	2.1	2.0			1910
Average	1.8	2.3	1.2	2.1	2.0	2.3	2.1	2.1	2.1	2.1			

[a] The capital series, representing net capital less residential structures, are found in Ohkawa, *Estimates of Long Term Economic Statistics*, Vol. 3, Tables 3, 5. Output estimates are compiled by Ohkawa, *The Growth Rate of the Japanese Economy*. A description of the procedures for constructing the LTES and Nakamura output series is found in note e to Table 1.

[b] Total, Sector 1 and Sector 2 refer, respectively, to capital-output ratios economy-wide, for the non-primary sector and for the primary sector.

TABLE 9
CHANGES IN THE RATES OF CAPITAL ACCUMULATION, SAVINGS, AND THE CAPITAL-OUTPUT RATIO: THE SIMULATED ECONOMY AND JAPAN[a]

	Simulation	Japan
Capital Accumulation	46%	44%
Savings Rate	5%	3%
Capital-Output Ratio	−11%	−24% (Ohkawa)
		−14% (LTES)
		−10% (Nakamura)

[a] For the first thirty periods (15 years), the specific calculations for each designated variable v are $[(v_{1900}/v_{1885}) - 1]100$. The average savings rate for Japan in the terminal year is taken as the average of the overlapping decades 1897-1906 and 1902-1911.

unchanging, small farm which utilized relatively small increases in capital inputs. Over a period of twenty-five years, agricultural output (net of intermediate inputs) per unit of labor increased by 89 percent; the gross output per unit of labor increased by 113 percent.[43] The Nakamura and LTES estimates provide a somewhat different characterization of Japanese labor productivity growth. Primary labor productivity increases by 33 and 53 percent in the Nakamura and LTES series, respectively, roughly comparable to the 52 percent of the model and in marked contrast to Ohkawa's 89 percent. The "Japanese miracle" vanishes in the LTES-Nakamura estimates– agricultural development proceeds at a much more moderate pace. Furthermore, in contrast to Ohkawa's estimates, but consistent with our model, labor productivity growth in non-primary production exceeds that of primary activities. Finally, in both Japan and the simulated economy the relative productivity growth differentials *increase* in early stages of development, only to *reverse* at a later stage. Differences in the rates of productivity change reach a peak around the turn of the century (and in period 30 of our model), after which a reversal in the trend is revealed. (Compare columns 11, 13 and 14.)

A key issue is one of identifying the sectoral rate and bias of technical change, particularly in agriculture. Since the agricultural labor force grew very slowly, if at all, and rates of capital accumula-

[43] All of the comparisons utilize net output. These measures were also employed by Ohkawa and Rosovsky in their study of agricultural productivity. See Ohkawa and Rosovsky, "The Role of Agriculture." In contrast, Hayami's examination of fertilizer demand in Japanese agriculture employs gross value produced per factor. See Yujiro Hayami, "Demand for Fertilizer in the Course of Japanese Agricultural Development," *Journal of Farm Economics*, XLVI (Nov. 1964).

TABLE 10

AVERAGE LABOR PRODUCTIVITY FOR THE SIMULATED ECONOMY AND JAPAN

Period	*Primary*				*Secondary*	
(Date)	*Simulation* (1)	*Ohkawa* (2)	*LTES* (3)	*Nakamura* (4)	*Simulation* (5)	*Ohkawa* (6)
1 (1885)	100.0	100.0	100.0	100.0	100.0	100.0
10 (1890)	104.3	114.3	105.6	102.3	109.0	104.9
20 (1895)	111.7	124.6	107.1	105.0	120.2	115.3
30 (1900)	121.8	148.6	120.6	111.5	132.7	135.9
40 (1905)	135.2	157.4	133.3	120.1	146.6	130.1
50 (1910)	152.2	189.1	153.3	132.5	162.1	151.7

Period	*Total*				*Relative Sectoral Productivities (Non-Primary/Primary)*			
(Date)	*Simulation* (7)	*Ohkawa* (8)	*LTES-Ohkawa* (9)	*Nakamura-Ohkawa* (10)	*Simulation* (5)/(1) (11)	*Ohkawa* (6)/(2) (12)	*LTES-Ohkawa* (6)/(3) (13)	*Nakamura-Ohkawa* (6)/(4) (14)
1 (1885)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10 (1890)	106.9	114.5	107.3	104.9	104.6	91.7	99.3	102.5
20 (1895)	117.4	130.0	119.1	116.9	107.6	92.5	107.6	109.8
30 (1900)	131.0	160.1	142.8	136.1	109.0	91.4	112.7	121.8
40 (1905)	147.9	166.4	151.1	142.3	108.5	82.6	97.5	108.3
50 (1910)	168.5	203.3	181.4	168.3	106.5	80.2	98.8	114.4

Note: The labor force series are compiled by Ohkawa, *The Growth Rate of the Japanese Economy*, p. 27. See also note e, Table 1.

tion in agriculture were low as well, then the primary explanation of Japanese success must rest with technical change. The implication is that the rate of technical change has been rapid and that it was labor-using in bias. While these are quantitative statements, a satisfactory study of Japanese technical change is yet to be undertaken, although descriptive accounts are readily available.[44]

Whether we utilize the Nakamura or the LTES estimates, the debate has revealed insights on the nature of technical change in both agriculture and industry which give support to our formulation. First, the concensus is that technology in agriculture was labor-using.[45] Second, consistent with the model predictions, the intensity of technical change in Japanese agriculture was almost certainly greater than that taking place in non-primary production. A range of 1.0 (Nakamura) to 1.7 (LTES) percentage rate of increase in agricultural output, in the absence of appreciable measured factor growth, can lead us to no other conclusion.

Sectoral Real Wages

Two measurement issues arise when comparing Japanese real wage experience with that in the simulated economy. First, in terms of the available historical data, are wages or annual earnings the relevant variables to compare with the trends in the simulation model? Second, what are the appropriate deflators of "money wages" to yield a real wage index relevant to firm decision making?

In agriculture two types of wage series are available, both con-

[44] The best study is by Watanabe who finds technical change to be labor saving in manufacturing, 1904-1933. See Tsuenehiko Watanabe, "Economic Aspects of Dualism in the Industrial Development of Japan," *Economic Development and Cultural Change*, XIV (April 1965), 293-312. Agriculture over the period 1887-1936 does *not* appear to reveal a significant bias. These are, as Watanabe later notes, highly tentative estimates. See Watanabe, "Industrialization, Technological Progress, and Dual Structure." The impossibility of simultaneously estimating the elasticity of substitution and the bias in technical change [P. A. Diamond and D. McFadden, "Identification of the Elasticity of Substitution and the Bias of Technical Change: An Impossibility Theorem," Working Paper No. 62, University of California (mimeo., March 1965)], weaknesses in existing data (output, capital excluding land improvements), and the necessity of making limiting assumptions all plague his empirical study.

[45] Ohkawa and Rosovsky, "The Role of Agriculture," p. 46; B. F. Johnston and J. Cownie, "The Seed-Fertilizer Revolution and Labor Force Absorption," *American Economic Review*, LIX (Sept. 1969), 569; B. F. Johnston and G. S. Tolley, "Strategy for Agriculture in Development," *Journal of Farm Economics*, XLVII (May 1965), 370; Shujiro Sawada, "Innovation in Japanese Agriculture, 1880-1935," in Lockwood, editor, *The State and Economic Enterprise in Japan*, p. 335; and Nakamura, *Agricultural Production and the Economic Development of Japan, 1837-1922*, pp. 141-42 and 149-50.

TABLE 11

REAL WAGES AND REAL ANNUAL EARNINGS PER LABORER: THE SIMULATED ECONOMY AND JAPAN[a]

Period (Date)	*Simulation Real Wage Index*[b] *(1)*	*Japanese Agriculture Male Workers*[c]		*Tussing Real Daily Wage Index: Construction Workers*[d] *(4)*	*Tussing Real Daily Wage Index: Manufacturing*[e] *(5)*	*Simulation Real Earnings Index*[f] *(6)*	*Tussing Real Annual Earnings Silk Reelings*[g] *(7)*
		Daily (2)	*Contract (3)*				
1 (1883-1887)	103.2	—	—	91.3	91.2	94.3	86.2
10 (1888-1892)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20 (1893-1897)	97.9	122.2	116.2	99.1	103.8	108.2	125.0
30 (1898-1902)	97.1	122.7	119.4	79.2	92.3	118.4	121.6
40 (1903-1907)	97.4	111.4	114.9	84.9	100.0	131.3	138.8
50 (1908-1911)	98.6	112.9	117.5	117.0	103.8	146.8	170.7

[a] 10 (1890) = 100. Data are not available on Japanese agricultural male workers' wages before 1890.

[b] $w(t)$, efficiency real wage index.

[c] Ohkawa, *Estimates of Long Term Economic Statistics*, Vol. 9, Table 34. Both wage rates are deflated by agricultural prices. *Ibid.*, Vol. 8, Table 10.

[d] Real daily wage for construction workers in Yamanashi Prefecture. A. R. Tussing, "The Labor Force in Meiji Economic Growth: A Quantitative Study of Yamanashi Prefecture," in K. Ohkawa, B. F. Johnston, and H. Kaneda, editors, *Agriculture and Economic Growth: Japan's Experience* (Tokyo: University of Tokyo Press, 1969), p. 213.

[e] Real daily wage in manufacturing in Yamanashi Prefecture. *Ibid.*, p. 214.

[f] $w(t)y(t)$, real earnings index.

[g] Real annual earnings in silk reeling. *Ibid.*, p. 215.

structed by Ohkawa. The first represents a weighted index of wages received by male daily or contract workers. The imputed value of meals received by daily workers is included in the wage. For contract workers the value of board and room is omitted; the series therefore understates the real wage level. Whether the trend in this series is biased depends on whether the value of income in kind changes through time as a proportion of the total real wage. The Ohkawa figures of daily and contract wages represent, with the qualification noted, the wage rate facing the firm. The corresponding series provided by the simulation model is the efficiency wage, w(t). (See Table 11.) We must recognize, however, that there are significant statistical problems inherent in compiling a composite wage index, given varying rates of labor augmentation from industry to industry, coupled with differential changes in labor force composition through time. These problems plagued Ohkawa in his compilations and as a result his wage series must be utilized with caution.

The second measurement issue involves the selection of an appropriate price deflator to obtain the real wage facing the firm. The relevant factor price for firm decision-making is the efficiency wage deflated by firm output price. Accordingly, the historical wage index must be deflated by the relevant *sectoral* commodity price to obtain an appropriate index of real wages facing the firm. A cost-of-living deflator, while commonly used in real wage comparisons, is inappropriate since it relates not to decision making of the *firm,* but rather to decisions of the *consumer.* The cost-of-living deflator may yield different results if the sectoral terms of trade and budget shares vary as development takes place.

Fortunately, the most serious of these estimation problems have been solved by Tussing's recent study which develops daily real wage *and* real earnings indices for Yamanashi Prefecture. The Tussing series also cover a longer time period, 1883-1887 to 1908-1911. The real earnings index is comparable to the simulation w(t)y(t) index while the real wage series should be compared with the simulated w(t) index. The simulated and Tussing series are remarkably alike. Tussing's construction and manufacturing real wage index declines to 1898-1902 and rises thereafter. The simulation model produces less dramatic movements, but it too declines up to period 30 and rises thereafter. (Compare columns (1) with columns (4) and (5).) Declining real wages do not necessarily imply deteriorating workers' living standards, however. Tussing's real *earnings* index and the simulation real earnings index both show impressive gains throughout the Meiji era. The only significant difference between the two series appears in the last half decade, 1903-1907 to 1908-1911. It would seem that the simulation model has fairly effectively reproduced Meiji Japanese experience with real wages and earnings.

COMPETING THEORIES AND THE LESSONS OF HISTORY

Accumulation and the Savings Effort

A widely accepted "lesson from history" is that significant changes in savings behavior represent a necessary condition for, and possibly a prerequisite to, successful economic growth. Rostow's "take-off," and Lewis' famous dictum that the central problem of development theory is to explain an increase in net savings rates from 5 to 12 percent, are both prominent examples. While these hypotheses appear plausible and command limited empirical support, savings may *not* have been *historically* the primary vehicle by which rapid rates of capital accumulation have been achieved.

The issue is clarified by a statement describing the determinants of capital formation in our modelled economy. Define gross national product by $G(t)$ and $\alpha_K(t)$ as the non-labor income share. Recalling that gross investment equals savings out of non-labor income, then $P(t)I(t) = sG(t)\alpha_K(t)$ and

$$\frac{\dot{K}(t)}{K(t)} = \frac{I(t)}{K(t)} - \delta = \alpha_K(t)$$

$$s\left[\frac{P(t)K(t)}{G(t)}\right]^{-1} - \delta = s^*(t)\left[\frac{P(t)K(t)}{G(t)}\right]^{-1} - \delta,$$

where δ is the depreciation rate, s is the savings *parameter,* and $s^*(t)$ is the overall gross savings rate. Rates of capital formation can therefore be explained by the joint movement of factor shares, the capital-output ratio *and* the savings rate. If historical forces produce either a rising non-labor income share and/or a falling economy-wide capital-output ratio, then rising rates of capital formation are fully consistent with a *fixed* savings parameter. Even a constant aggregate savings rate may be consistent with increasing rates of capital formation if the capital-output ratio should decline through time. Emphasis of these points is imperative since much of economic history has been written under the debatable assumption that modern industrialization can only be understood in a framework which isolates the causes of abrupt increases in an economy's capacity to save.

Both Meiji Japan and our simulated Asian economy demonstrate that phases of modern development with accelerating urbanization, industrialization, per capita income growth, and rates of capital formation are possible without major changes in savings behavior. Furthermore, secular increases in the rate of capital formation are far more dramatic than increases in the aggregate savings rate. Constancy in savings behavior does not imply stability in either $s^*(t)$ or in capital stock growth since the rate of capital formation is influenced both by shifts in income distribution and by changing capital-output ratios. It appears that the Rostow-Lewis conclusions must be significantly qualified. Indeed, our Asian prototype has an initial aggregate net savings rate of only .066 which over five decades increases to only .085. Yet the rate of capital accumulation rises from 2.3 percent per annum in the first decade to 4.1 percent in the fifth! Dramatic shifts in the savings rates were not required in "take off"; moreover, Meiji Japan did not find this necessary either. The share of net domestic capital formation in net national product rises only from .080 to .088 between 1887-1896 to 1907-1916 while the rate of capital accumulation increases from 1.9 to 4.4 percent per annum between 1885-1890 to 1905-1910. Table 9 offers a summary statement of these results. The rate of capital stock growth rises by 46 percent in the simulation and by 44 percent in Japanese history. Most of the explanation is found in the behavior of the capital-output ratio: in the simulation the rates decline by 11 percent; in Meiji Japan it declined by 24 (Ohkawa), 14 (LTES) or 10 (Nakamura) percent.

The "Sources-of-Growth" Methodology Versus Historical Counterfactuals in a General Equilibrium Framework

Do these findings suggest that increased savings might contribute little to early industrialization and growth? The answer is no. There are two related issues in making this assessment. First, what *is* the role of capital formation in economic growth? Second, what is the contribution of savings to capital formation?

Capital formation's primacy has been challenged recently by those theorists and historians employing the "sources-of-growth" methodology. The earliest contributors to this debate have been Abramovitz and Solow who have shown that technical progress is the main factor "explaining" economic progress in the United States; similar results have also been forthcoming for Chile, Greece, Taiwan, the Philippines, and even Mainland China.[46]

Criticism of this methodology has been extensive. For example, the sources-of-growth framework assumes (i) perfect competition in both product and factor markets, (ii) perfect aggregation, (iii) fully disembodied technical progress, (iv) a Cobb-Douglas specification, and (v) an approach which ignores the cumulative interaction of endogenous variables in the system. The latter assumption is critical. The sources-of-growth methodology effectively represents a taxonomic decomposition of factors "accounting for," but not necessarily "explaining," economic growth. It is therefore an accounting approach to a general equilibrium problem.

None of the sources-of-growth studies has assessed the sensitivity of the conclusions to the various assumptions of the model employed. Our study affords one such test. Our model *by assumption* satisfies competitive product and factor market conditions, aggregates perfectly, and is truly described by disembodied technical progress. In an experimental attempt to evaluate the technique, we have applied the sources-of-growth methodology to the simulated output series generated by our model. This represents a *counterfactual experiment* within a dynamic interdependent framework where the properties of the system are known with certainty. Using our model as the norm, discrepancies must be attributed to departures from the Cobb-Douglas specification and to cumulative and interaction effects. Paradoxically, our numerical analysis

[46] Robert Solow, "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics,* XXXIX (Aug. 1957); Henry Bruton, "Productivity Growth in Latin America," *American Economic Review,* LVII (Dec. 1967); A. C. Harberger and M. Selowsky, "Key Factors in the Economic Growth of Chile: An Analysis of Sources of Past Growth and Prospects for 1965-1970," Conference on the Next Decade of Latin American Economic Development, Cornell University, April 20-22, 1966; Samuel Bowles, "Sources of Growth in the Greek Economy, 1951-61," Memorandum No. 27, Project for Quantitative Research in Economic Development, Harvard University (mimeo., Nov. 1966); T. C. Liu, "The Tempo of Economic Development of the China Mainland, 1945-65," *An Economic Profile of Mainland China,* The Joint Economic Committee, Congress of the United States (Feb. 1967); and Williamson, "Dimensions of Postwar Philippine Economic Progress."

replicates the fundamental finding in the historical sources-of-growth literature: 70 percent of average industrial labor productivity growth is "explained by"(?) technical progress, or the residual! Does this imply a small role for capital formation even if technical progress is fully disembodied? Again the answer is no. The sources-of-growth calculation cannot answer that question.

There is, however, an appropriate counterfactual which *does* yield a meaningful answer: namely, by how much would historical rates of per capita output growth have been raised if the savings parameter had been increased by 1 percent? This experiment has been performed and the result is striking. By the end of one decade capital stock growth rates would have risen by 2.5 percent and output per capita growth by 3 percent.[47] What the sources-of-growth accounting obscures is how increased savings parameters foster industrialization-urbanization, more rapid rates of capital accumulation in future periods, and diminished population growth rates. These effects may be relatively unimportant for twentieth century advanced economies; they cannot be ignored for the nineteenth century low-income economy.

Labor Surplus, Labor Scarcity and Turning Points

In a recent article Tussing makes a point worth repeating: "The incomes of the common people rose substantially [during the Meiji era] . . . the Japanese did it mostly by working longer and working harder."[48] Tussing is referring to the large discrepancy between real annual earnings and real wage behavior in Yamanashi Prefecture up to World War I. Tussing's real wage data, presented in Table 11 shows a decline in real wages up to 1898-1902 and a rise thereafter. His real annual earnings index, on the other hand, exhibits continuous improvement from 1883-1887; indeed, the index rises from 86.2 to 170.7! These are the historical facts which competing theories must confront.

The emphasis which real wage behavior has received in the literature has been in response to an attempt to discriminate between alternative theories of factor pricing. Much of the confusion sur-

[47] Our percentage reference is to existing rates. For example, a 3 percent rise in growth rates may be from 3.0 to 3.1 in response to a savings parameter change from .312 to .315.

[48] A. R. Tussing, "The Labor Force in Meiji Economic Growth: A Quantitative Study of Yamanashi Prefecture," in K. Ohkawa, B. F. Johnston, and H. Kaneda, editors, *Agriculture and Economic Growth,* p. 220.

rounding "tests" of the labor-surplus model is attributable to the observation that real wages *have* remained constant over long historical time periods. Yet this is not a sufficient test since the periods studied may in fact be ones of stability in the overall capital-labor ratio. Nevertheless, real wage stability has also been observed during industrial revolutions. Recall the behavior of real wages in our simulated Asian growing economy. Real wages consistently (but modestly) *decline* over thirty "periods" of impressive growth! The neoclassical economy is therefore able to generate declining or stable real wages for even a growing economy. Those trends are hardly the exclusively property of the labor surplus model. Moreover, they do not necessarily imply that workers' living standards were constant or declining. In the simulated economy real *earnings* improve, as they did in Japanese economic history, and for the same reasons. In our model we label the cause "efficiency improvements" in labor; in the Japanese case Tussing refers to the phenomenon as "more intensive labor utilization."

The economic history of Meiji Japan has become the chosen battlefield for competing theories of the dualistic economy. In particular, Fei and Ranis have emphasized two key pieces of empirical evidence as support for the labor surplus formulation of the dualistic economy. First, they cite capital shallowing in industry between 1888 and the end of World War I as ". . . evidence that Japan made maximum use of her abundant factor, surplus agricultural labor."[49] But their data on capital shallowing is based on their own series of industrial capital stock, which has not only come under severe criticism, but is also at variance with several independent estimates.[50] Second, they emphasize the ". . . virtual constancy before and rapid rise of the real wage after approximately 1918 . . . [as] . . . rather conclusive evidence in corroboration of our theoretical framework."[51] However, in none of the several indices of real wages for Japan considered in a previous section were we able to identify constancy during the period they examine. Moreover, considering real wage trends over the classical period they identify

49 Fei and Ranis, *Development of the Labor Surplus Economy*, p. 132.

50 Most recently Colin Clark has reconstructed the capital stock series using the same procedure as Fei and Ranis (perpetual inventory) but employing different depreciation parameters. Clark's figures show capital deepening throughout the entire period under consideration. We are indebted to Professor Clark for permitting us to utilize his estimates before publication.

51 Fei and Ranis, *Development of the Labor Surplus Economy*, pp. 263-64.

as manifesting labor-surplus conditions (1888-1892 to 1908-1911), we find the real wage *increasing* by between 4 and 17 percent.[52] We conclude that the evidence supporting the labor-surplus formulation is highly questionable, *even when using the tests Fei-Ranis propose and employing the country and period they select.*

The Dynamics of Agricultural Backwardness

Early in this essay we reviewed the debate between the two views of agriculture in Japanese economic history. The "concurrent" growth thesis proposed by Johnston-Ohkawa-Rosovsky argues that modern economic growth in Japan was not preceded by an agricultural revolution, and that rapid growth in agricultural productivity took place simultaneously with industrialization. The competing "prerequisite" thesis argues for an agricultural revolution prior to modern economic growth.

One of the documented empirical characteristics of the developing economy is the persistent and wide productivity differentials between agriculture and industry. This characteristic is often cited as another aspect of dualism and reflects a "lagging," "backward" agricultural sector which places a "drag" on aggregate development. Furthermore, regional disparities in income per capita or labor productivity frequently increase during modern economic growth as well.[53] Is Japan unique in this regard? The LTES and Nakamura estimates on average sectoral labor productivity suggest the contrary (Table 10). The relative productivity of agricultural labor *declines* from 1885 to 1900 while it rises thereafter. To repeat, during the first two decades of modern Japanese growth, the relative productivity of agricultural labor deteriorates following a pattern found in most nations undergoing early industrialization. This result does not appear consistent with the Johnston-Ohkawa-Rosovsky thesis of "concurrent" agricultural growth.

Nevertheless, does this imply that agriculture was a relatively "backward" or "lagging" sector? The simulation reported in Table 10 reproduces with amazing similarity Japanese experience: sec-

[52] See Tables 6, 7. Minami also performed an econometric test for "turning points" in Japanese history. See Minami, "The Turning Point in the Japanese Economy," pp. 380-402. The results are difficult to interpret given the debate over the real wage series and aggregation problems.

[53] Jeffrey G. Williamson, "Regional Inequality and the Process of National Development: A Description of the Patterns," *Economic Development and Cultural Change,* XIII (July 1965), Supplement.

toral productivity differentials persist into late phases of growth. Yet, while industrial productivity growth initially outstrips that of agriculture, this pattern is subsequently reversed since agricultural productivity growth, although starting from lower rates, accelerates more rapidly throughout. These observed levels and trends in sectoral productivity growth can be readily explained. The reversal in relative growth rates in later phases results from the combined effects of more rapid increases in capital-intensity in agriculture during late development phases (the opposite is true in early growth phases) and from the differential rates of technical progress throughout. If an "agricultural revolution" is to be found in our simulation of Japanese experience, and if it is to be characterized by rapid increases in the accumulation of purchased inputs (that is, commercialization), it is centered on late growth phases, not early. Agriculture can hardly be characterized as relatively "backward" since it is enjoying more rapid rates of technical progress than industry.[54] Nor should agriculture be characterized as passing into a new *stage* of commercialization; instead, the process is cumulative and gradual. Finally, the relatively low rates of productivity growth in agriculture in the early phases of modern economic growth can hardly be viewed as evidence of the sector's "drag" on development. In spite of sluggish initial productivity growth, the increased allocation of investment resources to agriculture early in the industrialization process would have been sub-optimal in the modelled economy and, presumably, in Japan as well.

A final observation merits emphasis. Of particular interest is the early period of capital shallowing in Japanese agriculture (Table 5). Labor-using technical change in agriculture, taking the form of increased utilization of improved techniques, fertilizers, and seeds, played an important role in raising agricultural productivity.[55] Indeed, both the bias and the rate of technical change in agriculture have often been cited as the key to explaining the success of Japanese development. This historical experience has been quite effectively captured in the simulation model. This confirms

[54] Kelley, Williamson, and Cheetham, "Biased Technological Progress."

[55] Ohkawa and Rosovsky, "The Role of Agriculture"; Ohkawa and Rosovsky, "A Century of Japanese Economic Growth"; Yujiro Hayami, and Saburo Yamada, "Technological Progress in Agriculture," in Lawrence Klein and K. Ohkawa, editors, *Economic Growth, the Japanese Experience Since the Meiji Era*; and Johnston and Cownie, "The Seed-Fertilizer Revolution."

the importance which those concerned with "unemployment" place on agriculture as a potential labor-absorbing sector. Given rapid rates of labor-using technical change in agriculture, increases in labor intensity play a major role in absorbing labor force increments in early growth phases when capital accumulation is less rapid. This phase of agricultural development, while relatively brief, may be critical.

Stages or Phases?

Japan has frequently been described in terms of discontinuities, stages, turning points, and take-offs. We have argued throughout this section that a model with a fixed structure and stable parameters is quite capable of explaining Japanese growth. That is, it reproduces growth *phases*. Furthermore, and most important, the transition from one phase to another is fully endogenous to the model.

It might be useful to summarize our main conclusions at this point. First, rising rates of capital accumulation and per capita output growth can be observed in history without abrupt changes in savings behavior *or* in aggregate national savings rates. Take-offs are fully consistent with a dynamic model with stable parameters. Second, phases of accelerating output growth and capital accumulation are also consistent with unusually rapid rates of industrialization and urbanization. There are no "leading" or "lagging" sectors to be identified. The source of change in economic structure is the augmentation of capital and labor services by accumulation and by factor-augmenting technical change. Third, the simulated Asian economy produces phases of real wage decline and real wage expansion. It has not been necessary to appeal to "commercialization" or "turning" points to yield this result. A neoclassical model of wage determination has been sufficient to explain real wage behavior in *both* phases. Finally, Fei and Ranis argue that Japanese industry experienced a declining labor share up to World War I and a rise thereafter. They feel that these results confirm their labor surplus interpretation of pre-1918 Japanese experience and the reversion to neoclassical conditions thereafter. Although the results are not reported here, our neoclassical model also generates phases of factor share movements consistent with the historical record. In short, our dualistic economy produces phases of development reminiscent of Rostovian stages but does not rely on parameter shifts or changes in model structure to yield such historical behavior.

The Japanese Miracle and Population Growth

We return to a theme raised early in this article. Even though the *structure* of Japanese growth is fairly consistent with our modelled contemporary Southeast Asian economy, to what extent can the "Japanese miracle" in terms of the *pace* of development be explained by unusually low rates of population and labor force expansion? The tentative evidence presented in a previous section and elsewhere[56] suggests that much of Meiji Japan's impressive performance can be explained by unique demographic features. In most key aspects, the modelled Southeast Asian economy generates a development trajectory and structural change very similar to Japan. Much work remains to be done on this issue, especially given the pressing contemporary problems in Asia with the current labor force explosion. However, if our tentative findings are supported by further quantitative research, then the relevance of Japanese experience as a contemporary lesson must be carefully qualified. Contemporary Asian nations may mistakenly look to Meiji Japanese history as a model of what is feasible. Given their limited control over demographic variables to date, the lesson of history may not only be irrelevant, but cruel.

CONCLUDING REMARKS

This article illustrates the value of dynamic interdependent economic models in historical analysis. It utilizes the tools of growth theory, but relies on simulation in analyzing an economy undergoing unbalanced growth. Following an earlier suggestion by Leontief, the parameters of the model are estimated using contemporary data (Southeast Asia). This framework is then used to rewrite the economic history of Meiji Japan; indeed, the result is to write economic history backwards. Since we have had considerable success in this exercise, we are now far more confident that the lessons of Meiji Japanese experience are relevant to contemporary growth problems in Southeast Asia. Furthermore, our success suggests the potential for further applications of simulation models to problems

[56] Kelley, Williamson, and Cheetham, *Economic Dualism in Theory and History*, chs. v, vi, and ix.

in economic history. Many historical counterfactuals can *only* be investigated with dynamic interdependent models. The validity of these counterfactual experiments depends critically on the ability first to rewrite historical experience through simulation.

The study highlights a number of important issues relating to Japanese growth which have been obscured due to the intense debate over measurement. First, we argue that demographic factors played an enormously important role in Japanese growth; indeed, much of the "Japanese miracle" can be explained by its somewhat unique population growth rate. Second, the simulation model is capable of producing Rostovian phases of growth although the model is fixed in structure with stable parameters. This result suggests that economic historians may have exaggerated the importance of institutional and behavior change in explaining industrial revolutions and modern economic growth. Third, it appears that the labor surplus framework is an inferior interpretation of Japanese growth experience and, further, that declining real wages during early industrialization is readily explained in a neoclassical framework. Yet this does not necessarily imply a deterioration in workers' living standards. Fourth, significant changes in aggregate savings behavior are not necessary to generate either accelerating rates of capital formation or growth. This does not necessarily imply, however, that shifts in savings behavior have a small impact on growth. Fifth, we evaluate *quantitatively* the relevance of the sources-of-growth methodology in "explaining" growth. In the Japanese case at least, the sources-of-growth methodology appears to be a misleading approach to a general equilibrium problem. Finally, we analyze the role of agriculture in economic growth and show that even a technologically progressive agricultural sector typically obtains rates of productivity growth less than non-agriculture in early growth phases.

Allen C. Kelley and Jeffrey G. Williamson,
University of Wisconsin

APPENDIX

Table A lists parameters and initial conditions utilized in a previous section. They are drawn from contemporary Asian economies. An extensive discussion of these estimates can be found in Kelley, Williamson and Cheetham [1971]. Capital-labor ratios are denoted by $\hat{k}_i$, $s^*(0)$ refers to the aggregate gross national savings rate, and α is labor's share in national output.

TABLE A
PARAMETER VALUES AND INITIAL CONDITIONS
UTILIZED IN SIMULATIONS

Parameters	*Initial Conditions*	
$A_1 = 0.640$	$x(0) = y(0) = 1.000$	$u(0) = 0.300$
$A_2 = 0.350$	$K(0) = 30.174$	$v(0) = 0.429$
$\sigma_1 = 0.500$	$K_1(0) = 17.135$	$s^*(0) = 0.150$
$\sigma_2 = 1.500$	$K_2(0) = 13.039$	$\alpha(0) = 0.481$
$\lambda_K = 0.003$	$L(0) = 100.000$	$\hat{k}_1(0) = 0.571$
$\lambda_L = 0.010$	$L_1(0) = 30.008$	$\hat{k}_2(0) = 0.186$
$n_1 = 0.020$	$L_2(0) = 69.992$	$\hat{k}(0) = 0.302$
$n_2 = 0.030$	$Q_2(0) = 94.990$	$\frac{P(0)K(0)}{GNP} = 1.854$
$\delta = 0.050$	$P(0)Q_1(0) = 71.290$	
$\beta_{11} = 0.800$		$n(0) = 0.027$
$\beta_{12} = 0.500$		
$\beta_{21} = 0.200$		
$\beta_{22} = 0.500$		
$\gamma = 0.648$		
$s = 0.302$		