Population Change and Economic Development: Lessons from the Japanese Experience, 1885-1920

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ABSTRACT

Using a long-run supply-oriented model estimated for the so-called "miraculous take-off" period of the Japanese Meiji economy, this study aims at clarifying the way demographic factors are interwoven with socio-economic variables. The constructed simulation model is utilized for analyzing the relevance of the early Japanese experience to contemporary developing countries, particularly in Asia.

One of the primary findings is that if the Meiji economy had faced the same population growth pattern as in modern Asian developing countries, the Meiji economy would have been unabale to follow the sustained growth path it had actually experienced. This result is attributable to the difference in the mortality pattern between Meiji Japan and contemporary Asia. Although the mortality pattern is pronouncedly different between them, the fertility aspect of Meiji Japan seems to have a substantial degree of compatibility with Asian developing countries. For this reason, further analyses of the fertility behavior of Japan in its early stages of development might yield findings useful to developing countries in Asia.

I. Introduction

In recent years, an increasing number of governments of developing countries have become more aware of the serious challenge of rapid population growth to their social and economic development. Yet, population factors have been integrated into development planning schemes only to a limited extent, primarily because of inadequate knowledge of various important interactions among population and socio-economic variables. To supply this knowledge, a systematic and comprehensive framework for analyzing the effects of population changes upon an economic system is urgently needed.

This paper attempts to furnish a clearer understanding of the way demographic factors are linked to social and economic development, by drawing upon a long-term simulation model constructed on the first thirty-five years of the Japanese modernizing process. When the model is modified to incorporate demographic factors, it permits us to explore how Japanese demographic conditions contributed to the "Japanese miracle" of early economic progress. Furthermore, we aim at exploring the relevance of the early Japanese experience to comparable modern developing countries, particularly in Asia, in hopes of providing a useful basis for them to formulate more effective population planning policies in their development schemes.

II. Dualistic Economic Development of Meiji Japan

Japan has been described by some economists as the classic example of dualistic economic development (Fei and Ranis, 1964). In this section, let us briefly discuss a few fundamental economic elements underlying the dualistic processes of pre-war Japan.

In 1867, Japanese feudalism, which had lasted for several centuries, ended with the collapse of the Tokugawa Shogunate, and the Meiji Government was established in 1868. One of the primary political concerns of the new government was to mobilize all available resources to widen and strengthen its economic base for industrialization. Due to the mounting Japanese fear of colonization by advanced foreign powers, the Meiji Government avoided any major inflow of capital from Western countries.[1/] Consequently, most of the financial resources required for industrialization had to be generated internally, particularly from the agricultural sector.

After having emerged from long-lasting feudal social and economic relations, Meiji farmers adapted themselves with remarkable rapidity to new cultivation techniques and new market conditions. The annual average growth rate of agricultural productivity increased from 0.1 percent to the range of 0.8 to 1.2 percent in early Meiji (Nakamura, 1965). This rapid increase was brought about through heavy utilization of fertilizers, improvement of irrigation and drainage systems, and the adoption of new agricultural technologies, including superior seeds and better cultivation methods. It is interesting to note that from 1878 to 1882 paddy yields per hectare were estimated to be in the vicinity of 63 bushels, a productivity level that corresponds to that of developing countries in Asia in the 1960s (Rovosky, 1961). This equivalence of yields may underscore applicability of the Meiji experience to some of the contemporary developing countries in Asia.

This adaptation in rural sectors occurred with little financial assistance from the urban sector or the government. Rather, it was rural sectors that financed strenuous efforts for modernization in urban sectors.

The transfer of financial resources from rural, agricultural to urban, modern sectors was institutionalized by the Land Tax Reform of 1873 (Ogawa, 1980). With the surplus siphoned off from the agricultural sector, the Meiji Government took strong initiative in launching a variety of industrialization projects. One of the principal inputs required for industrialization under state patronage was imported technologies and machinery from advanced Western countries. Besides imported equipment, services of foreign experts were also provided to many government-operated enterprises. As a result of the massive importation of such foreign industrial goods, Japan's balance of payments was in large deficit, especially in early stages of Meiji development (Lockwood, 1954). In early Meiji, export commodities were basically primary products such as raw silk, silver, copper and lacquerware.

From the beginning of the 1880s government factories and businesses were transferred at bargain prices to private businesses. This created a number of leading industrial combinations (Zaibatsu). The sales of government-owned industrial facilities to private entrepreneurs contributed to the take-off of Japanese economic development.

In addition to capital, the agricultural sector supplied its surplus labor to industrial sectors. Rural areas had been densely inhabited by the end of Tokugawa feudalism, and the shift of the agricultural surplus labor to urban areas was facilitated by a rapid increase in demand for labor in urban, modern sectors. Increased labor mobility was further accelerated by aggravated economic conditions in rural sectors created by heavy land taxes.[2/]

With both capital and abundant labor, Japan completed its take-off stage around the turn of the century, and entered Rostow's so-called "drive to maturity" stage (Rostow, 1960). It is widely-documented that there were three leading initiators of the Japanese economic take-off, i.e., the textile industry, the railway industry and the mining of coal (Ogawa, 1980). The textile industry, in particular, was an example of remarkable success under private entrepreneurship. Through successful import substitution, the production level of this industry quadrupled from 1887 to 1890. The volume of cotton products exported surpassed that of their import in 1897, and in 1918 Japan exceeded both U.S. and India in the amount of cotton fabric exported in the world economy.

Following the rise of the light industry exemplified by the textile industry, heavy industry started to move rapidly along its growth path. Iron and steel factories were established at the beginning of the 20th century. At the same time, other related heavy industries began to prosper including metallurgy, machinery and equipment, and shipbuilding. One may consider Japanese industrial capitalism as fully established by the 1900s (Rosovsky, 1961). As shown in Figure 1, the level of non-agricultural production rose substantially in the early 1900s, especially after the Russo-Japanese War (1904-1905). In 1895, light industry constituted approximately 80 percent of total industrial production. As a result of the magnificent growth of heavy industrial sectors, however, it dropped to 62 percent in 1920.

The upsurge of militarism also contributed to Japanese industrial growth. Industrial production levels were greatly affected by the Sino-Japanese War (1894-1895), the Russo-Japanese (1904-1905) and World War I (1914-1918). Almost 55 percent of the national and local expenditures for the entire Meiji period was required for state services including military outlays[3/] (Oshima, 1965).

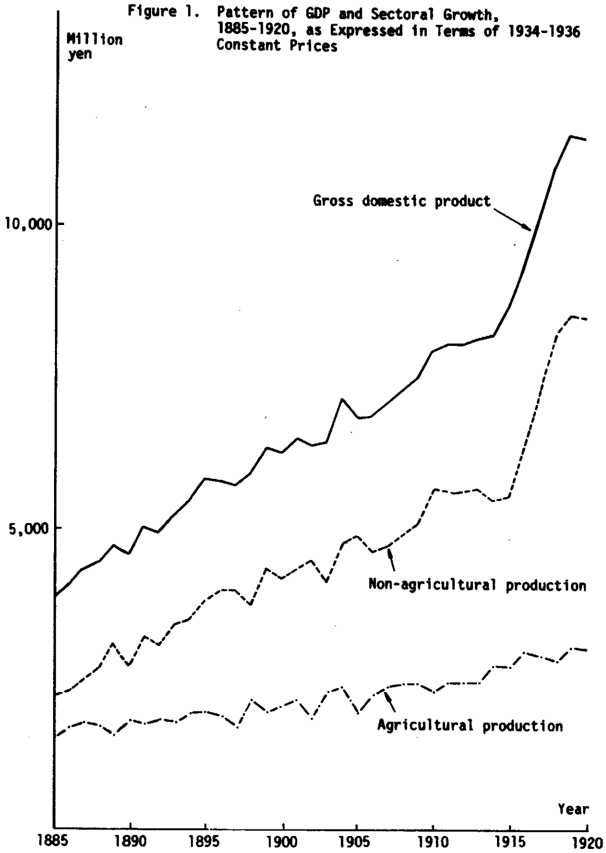


Figure 1. Pattern of GDP and Sectoral Growth, 1885-1920, as Expressed in Terms of 1934-1936 Constant Prices

III. Demographic Changes in the Pre-census Period

Japan conducted its first population census in 1920. Prior to this date, publication of vital statistics had begun in 1900, and despite questions of reliability of the data, several demographers have attempted to use the official statistics to estimate population growth and its changes during the period before the first census. Among these, estimates by Okazaki and Yasukawa, made on the basis of the 1920 population census by the reverse survival method, are most often cited (Okazaki, 1962; Yasukawa and Hirooka, 1972). Table 1 compares their estimates of total population, and crude birth and death rates. Okazaki's estimate of total population exceeds that of Yasukawa's in early Meiji while the opposite is the case in later years of the estimation period. A later analysis (Ohbuchi, 1976) concludes that the Okazaki estimate might contain an upward bias at the beginning of the Meiji Era, but that the Yasukawa estimate appears

Table 1. Comparison of Population Size and Vital Rates, 1870-1920

	Yasukawa Estimate			Okazaki Estimate		
	Total Population (Thousands)	CBR	CDR	Total Population (Thousands)	CBR	CDR
1870	35,384	30.9	25.8	36,288		
					36.3	31.3
1875	36,528	34.4	26.1	37,198		
					36.4	31.3
1880	38,174	33.9	26.6	38,166		
					33.9	28.3
1885	39,634	32.2	25.9	39,245		
					33.7	28.1
1890	41,020	32.1	25.3	40,353		
					34.3	27.3
1895	42,472	33.8	24.9	41,789		
					36.3	27.0
1900	44,392	35.6	25.0	43,785		
					35.2	24.2
1905	46,825	34.4	24.8	46,257		
					37.0	25.3
1910	49,637•	36.9	24.2	49,066		
					35.6	22.1
1915	52,949	35.4	23.4	52,500		
					33.2	22.3
1920	55,963	38.1	21.8	55,450		

Source: Yasukawa and Hirooka (1972) and Okazaki (1962)

to have no gross fault. More important, the latter follows the economic trend and cyclical variations better than the former.

As illustrated in Table 1, both Yasukawa and Okazaki estimates show relatively slow population growth in early Meiji. In both, the rate of population growth exceeds 1.0 percent during the period of 1900-1905. This rise in the population growth rate is attributable principally to a considerable decline in mortality and a modest rise in fertility. These demographic changes were brought about by the gradual disappearance of infanticide and improved living conditions as a result of economic development. The population growth rate reached its peak over the period 1910-1915, in the case of the Okazaki estimate. On the other hand, the Yasukawa estimate shows the highest population growth rate in 1920. After 1920 observed data indicate a sustained reduction of fertility. Although the two sets of estimates produce similar results when employed in regression equations (see Appendix A), for consistency, the Okazaki data have been used throughout.

IV. Earlier Models

In the past years a limited number of long-term econometric models for pre-war Japan have been developed. These growth-oriented models, however, have been designed primarily to analyze changes in pre-World War II economic activities, and demographic factors have been treated in an extremely limited and crude manner. Among these models, the Kelley and Williamson model developed for pre-war Japan over the period of 1887-1915 deserves attention (Kelley and Williamson, 1974). In their model, population growth affects the economy through its positive effect on savings and capital accumulation due to a reduction in labor's share, and through its negative impact on the growth of the capital-labor ratios. The net impact of population growth is, therefore, subject to the interaction between these two opposing effects. By tripling the population parameter, Kelley and Williamson quantified the magnitude of the impact of the high population growth rates prevailing in the contemporary developing world. Their conclusion is somewhat surprising: the contemporary population pressure would have exerted a minimal impact on Meiji economic development. Based on this finding, Kelley and Williamson concluded that the Japanese economic historian's preoccupation with non-demographic determinants of Japanese economic growth represents a well-placed emphasis.

Following the Lewisian theory of economic development, Minami and Ono (1957) built an econometric model for pre-war Japan covering the period of 1906-1940. Their model was formulated so as to test several hypotheses including the effect of population growth upon disguised unemployment and wage differentials, and to analyze structural effects of total and working-age population upon the Japanese economy. Minami and Ono attempted to treat both birth and death rates as endogenous variables, but met with limited success. Nevertheless, it is important to note that population structural changes were included in the model in the context of capital formation, which in turn, would effect the level of output.

Prior to the model by Minami and Ono, Odaka and Ishiwata (1972) constructed an economic growth model with stress on the interactions of demand and supply. This model, which was estimated for the period of 1906-1938, aimed at explaining the phenomenon of cyclical growth in pre-World War II decades. In their model, they included total population size only as a component of the consumption function. The population factor, therefore, was treated marginally.

Using an extremely simplified version of the framework of the Coale-Hoover type, Tachi and Okazaki (1965) presented the relationship between population growth and economic changes over the period of 1882-1937. They concluded that higher Japanese population growth would have reduced total savings, and consequently would have slowed the pace of capital formation. Because their system has proven to be too simplified, however, the interpretation of these computed results needs appropriate caution.

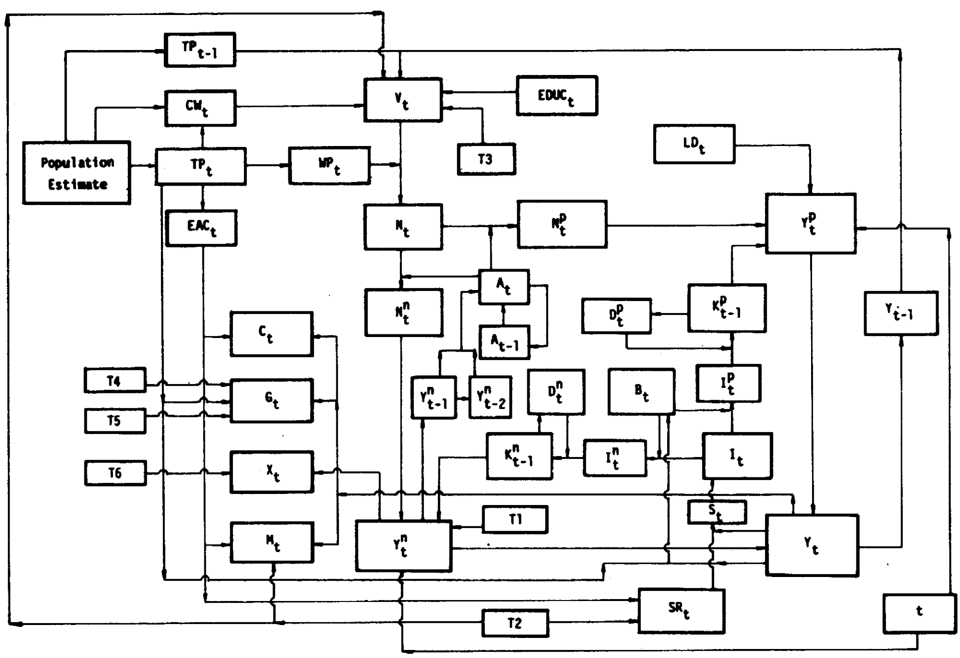
V. A New Model

From the above review of the previous attempts at modelling the pre-war Japanese development process and population changes, it is clear that the simulation model presented here is the first endeavor to treat population factors explicitly and with a level of sophistication and elaboration adequate for the analysis of early Japanese development.

We propose a two-sector model, comprised of "primary" and "non-primary" industry, designed to capture the dualistic process of early Japanese development. Following conventional growth economics, the model has been framed to describe a development path at full employment. That is, the structure assures the ex ante equality of investment and savings.

The structural relationships of the model have been estimated on the basis of annual aggregate data over the period of 1885-1920. This data period corresponds to the take-off of Japanese economic development and its subsequent path to maturity, and was chosen for the following reasons. Firstly, for the construction of the economic system, we have heavily drawn upon data published by K. Ohkawa and his associates in Estimates of Long-term Economic Statistics in Japan Since 1868 (LTES), and most of the data we have employed in the present study are available only after 1885. Secondly, in terms of the development of the Japanese demographic data base, the year 1920 marked by the first nation-wide Japanese census, is a critical cut-off point. Thirdly, because by the year 1920, Japanese industrialization was well under way toward its maturity stage (Rostow, 1960), the period leading up to that date appears to have the greatest relevance for contemporary developing regions.

Diagram 1. Schematic Flow Chart of the Simulation Model



Notation

Y = gross domestic product (millions of 1934-36 yen)

C = personal consumption (millions of 1934-36 yen)

G = government spending (millions of 1934-36 yen)

M = imports (millions of 1934-36 yen)

X = exports (millions of 1934-36 yen)

K = end-of-year capital stock (millions of 1934-36 yen)

D = depreciation (millions of 1934-36 yen)

N = labor force in thousand persons

LD = agricultural land stock (thousands of hectares)

TP = total population in thousand persons

EAC = equivalent adult consumer unit

CW = child-woman ratio

WP = working-age (10-64) population in thousand persons

V = labor force participation rate

EDUC = enrollment rate in compulsory education

T1 = deletor variable (T1 = 1 in 1895)

T2 = deletor variable (T2 = 1 in 1905)

T3 = deletor variable (T3 = 1 in 1915)

T4 = dummy variable (T4 = 1 in 1894 and 1895)

T5 = dummy variable (T5 = 1 in 1904, 1905 and 1906)

T6 = dummy variable (T6 = 1 in 1919 and 1920)

n = non-primary sector

ρ = primary sector

A = proportion of the labor force engaged in the primary sector

B = proportion of gross savings in the non-primary sector

t = time

SR = saving rate

S = savings (millions of 1934-36 yen)

I = investment (millions of 1934-36 yen)

To facilitate our discussion, the theoretical linkage of the simulation model is depicted in Diagram 1. The simulation model comprises twelve behavioral equations, and eleven identities and definitions. The coefficients of each equation have been estimated by ordinary least squares. All the demographic coefficients have been computed on the basis of the Okazaki data.

Production Function for the Primary Sector

$$(1) \quad Y_t^p = [\, 0.157 - 0.000126\, t - 0.00011\, t^2 + 0.0000048\, t^3 - 0.000005\, (t - 12)^3 \cdot D1 + 0.000001\, (t - 24)^3 \cdot D2\,] \cdot [\, e^{0.0114} \cdot K_{t-1}^p\,]^{0.196} \cdot [\, e^{0.0194} \cdot N_t^p\,]^{0.524} \cdot LD_t^{0.280}$$

The gross domestic product of the primary sector is determined by time (t) and three productive inputs available in this sector, namely, capital (k), labor (N) and the agricultural land stock as measured in terms of paddy field acreage (LD).

When we attempted to apply the conventional Cobb-Douglas production function, the estimated coefficient for capital proved to be negative. This unsatisfactory result was in agreement with earlier empirical findings of a study over the comparable time period (Minami, 1973). For this reason, we have adopted the estimated parameters and coefficients for K, N and LD for the Cobb-Douglas production function utilized by Kelley and Williamson (1974). Based upon a study previously done by Yamada and Hayami (1972), Kelley and Williamson set factor shares in the total cost of agricultural production as follows: capital share = 0.196, labor share = 0.524, and land share = 0.280. Moreover, we have applied factor-sugmenting technical changes to both capital and labor; these efficiency-oriented units of the productive inputs, as distinguished from the conventional physical units, are crucial to understanding the development of contemporary developing countries as well as Meiji growth experience. By slightly modifying estimates computed by Yoshihara (1972) for the interwar period, Kelly and Williamson selected 0.0194 for labor and 0.0114 for capital stock. The difference between these two parameters reflects a labor-augmenting-bias view of Meiji Japanese History.[4/]

Given these parameters, we have estimated the pattern of the residuals as a function of time. As shown in equation (1), this residual component is expressed as a spline function, D1 and D2 being dummy variables (Suits, Mason and Chan, 1978). D1 = 1 if t is greater than 12, and is otherwise 0. D2 = 1 in the range where t is greater than 24, and is otherwise 0.

Production Function for the Non-primary Sector

$$(2)\quad Y_t^n = [\,0.9985\,] \cdot [\,e^{t\,(0.485 + 0.185\,T1 - 0.120\,t + 0.0134\,t^2 - 0.00054\,t^3 + 0.00054\,(t-8)^3 \cdot D3 + 0.000001\,(t-17)^3 \cdot D4)} \cdot K_{t-1}^n\,]^{0.803} \cdot [\,e^{t\,(0.823 + 0.315\,T1 - 0.205\,t + 0.023\,t^2 - 0.001\,t^3 + 0.0009\,(t-8)^3 \cdot D3 + 0.0000016\,(t-17)^3 \cdot D4)} \cdot N_t^n\,]^{0.197}$$

Mainly because most of the industrial sector promoted capital-intensive and labor-saving production modes over the period under study, the production function for the non-primary sector involves capital stock with a lag of one year and labor currently employed.

Kelley and Williamson have used the CES production function on the basis that Meiji industry drew heavily upon imported Western technology, thus permitting only a limited range of factor substitution (Watanabe, 1968). We have, however, utilized the Cobb-Douglas production function, which features unitary elasticity of substitution, for the following two reasons. Firstly, as compared with the CES function, the Cobb-Douglas function is much simpler in form, thus requiring less computational efforts and making its interpretation easier. Secondly, the performance of CES and Cobb-Douglas functions yield almost the same results for the time period in question.

As was done for the primary production function, the parameters for factor shares are directly adopted from the Kelley and Williamson study. This Cobb-Douglas production function also incorporates technical factor-augmentation. The rates of augmentation through technical change to labor and capital have been computed in the following two steps. First, the selected values of parameters were incorporated in a conventional Cobb-Douglas production. This was then applied to the observed data to obtain a set of residuals. The trend of the residuals was then estimated by a linear spline function of time. The year 1895 was deleted as an out-lier, (T1 = 1 for the year 1895).

Saving Rate Function

$$(3) \quad \ln \left[(0.4 - SR_t)/SR_t \right] = 2.601 - \underset{(0.745)}{9.818} (Y_t/EAC_t) + \underset{(0.157)}{0.576} \, T2$$

$$D - W = 0.990 \; ; \; R^2 = 0.847$$

In our model, one of the important propellents of the Meiji economy is savings which contribute to capital accumulation. The level of savings is accounted for by GDP per EAC. It should be stressed, however, that a deletor variable T2 (T2 = 1 in 1905) has been included in the function to capture the irregularity of the savings level due to the effect of the Russo-Japanese War.

To avoid possibilities of plunging into a negative saving rate or exceeding a reasonable ceiling rate, we have estimated the saving rate function in a logistic form with the range of 0 to 0.4. The rational for selecting 0.4 as the ceiling is that the highest saving rate recorded in Japan is slightly less than this.

Standard errors are noted in parentheses under the estimated regression coefficients.

Savings Allocation Function

$$(4) \quad \ln \left[(0.9 - B_t)/B_t \right] = 3.818 - \underset{(1.56)}{34.371} (GDP_t/TP_t)$$

$$D - W = 1.253 \; ; \; R^2 = 0.934$$

Gross savings are allocated between the two sectors on the basis of per capita GDP which reflects stages of economic development. In a rapidly-growing economy where industrialization is a core of its development, an increasing amount of gross savings needs to be invested for further expansion of its non-primary productive capacity.

It should be noted, however, that we have set a ceiling for this allocative mechanism, not to exceed a critical minimum level of the primary component of GDP. Thus, we have employed the logistic equation as expressed in equation (4). We have selected a value of 0.9 for the ceiling, on the basis of current Japanese economic data.

Depreciation Function for Primary and Non-primary Sectors

$$(5)\quad D^p_t = 21.457 + \underset{(0.001)}{0.0137}\, K^p_{t-1}$$

$$D - W = 0.157\ ;\ R^2 = 0.912$$

$$(6)\quad D^n_t = 50.343 + \underset{(0.001)}{0.0694}\, K^n_{t-1}$$

$$D - W = 0.292\ ;\ R^2 = 0.994$$

In the production functions, as expressed by equations (1) and (2), capital stock appears in net terms, so that adjustment is necessary to allow for depreciation in each sector.

Labor Force Participation Rate Function

$$(7)\quad V_t = 0.575 - \underset{(0.0002)}{0.0000163}\, CW_t - \underset{(0.0003)}{0.00015}\, EDUC_t + [\ - \underset{(2.27)}{0.0637}\, (Y_{t-1}/TP_{t-1}$$

$$+ \underset{(27.8)}{42.32}\, (Y_{t-1}/TP_{t-1})^2 - \underset{(107.2)}{210.66}\, (Y_{t-1}/TP_{t-1})^3$$

$$- \underset{(1859.3)}{846.19}\, (Y_{t-1}/TP_{t-1} - 0.14)^3 \cdot D1\ ] \cdot D2 - \underset{(0.04)}{0.094}\, (1 - D2) \cdot$$

$$\ln\, (Y_{t-1}/TP_{t-1}) + \underset{(0.01)}{0.0194}\, T2 - \underset{(0.008)}{0.0293}\, T3$$

$$D - W = 1.149\ ;\ R^2 = 0.958$$

The labor force participation rate (V), as measured in terms of the ratio of the labor force (N) to the working-age population aged 10-64 (WP), is determined by the following three variables: the percentage of student enrollment in compulsory education (EDUC), the child-woman ratio (CW), and per capita GDP (Y/TP). In the long run, improved educational levels tend to contribute to greater employment opportunities for women in urban modern sectors. On the other hand, an increase in student enrollment rates leads to a loss of child labor, particularly in rural areas. The net outcome of these opposite labor effects can be statistically measured. The regression result indicates that the latter effect exceeds the former.

As discussed in depth elsewhere, higher fertility tends to depress female labor force participation. The child-woman ratio is, therefore, expected to have a negative impact on the labor force participation rate. In addition, the level of economic development, as represented by Y/TP, may stimulate the labor force participation rate as a result of increased demand for labor and rising wage rates in modern, industrial sectors. To capture nonlinearity, we have used a spline function. The D_i are dummy variables which take a value of 1 in the range as shown below and are otherwise 0.

Variables	Equals 1 when
D_1	$0 < Y_{t-1}/TP_{t-1} \leqq 0.140$
D_2	$0 < Y_{t-1}/TP_{t-1} \leqq 0.163$

In addition to these explanatory variables, we have included in this equation two deletor variables reflecting irregularities due to war influences, i.e., T2 = 1 for 1905 and T3 = 1 for 1915.

Rural-Urban Migration Function

$$(8)\quad A_t = -\ 0.0176 + \underset{(0.003)}{1.016}\ A_{t-1} - \underset{(0.003)}{0.00012}\ [\ (Y^n_{t-1}/Y^n_{t-2}) - 1\ ]$$

$$D - W = 1.004\ ;\ R^2 = 0.999$$

In this model, the labor force, which is the product of V and WP, can be divided into the labor force engaged in the primary sector and that engaged in the non-primary sector. Changes in A, the proportion of total labor force in the primary sector, may be accounted for by a lagged rate of increase in non-primary output. An increase in the production of urban, non-primary sectors required an expanded supply of labor to migrate from rural, primary sectors.

In order to make our supply-oriented equilibrium growth model complete as a theoretical system, we need the following identities and definitions:

$$(\ 9)\quad Y_t = Y^p_t + Y^n_t$$

$$(10)\quad S_t = SR_t \cdot Y_t$$

$$(11)\quad S^p_t = (1 - B_t) \cdot S_t$$

$$(12)\quad S^n_t = B_t \cdot S_t$$

$$(13)\quad I^p_t = S^p_t$$

(14) $I_t^n = S_t^n$

(15) $K_t^p = K_{t-1}^p + I_t^p - D_t^p$

(16) $K_t^n = K_{t-1}^n + I_t^n - D_t^n$

(17) $N_t = V_t \cdot WP_t$

(18) $N_t^p = A_t \cdot N_t$

(19) $N_t^n = (1 - A_t) \cdot N_t$

In the above, we have already linked the supply component to part of the demand side in connection with savings and investment as expressed by (13) and (14). Let us now look into other elements of aggregate demand on a function-by-function basis.

Consumption Function

(20) $$C_t = 854.42 + \underset{(0.04)}{0.0048}\, EAC_t + \underset{(0.07)}{0.658}\, Y_t$$

$$D - W = 0.957 \; ; \; R^2 = 0.985$$

The consumption function, which is of a Keynesian type, comprises GDP (Y), and total population adjusted by adult equivalent consumer units (EAC). Following the previous study (Ogawa, 1979), weights for EAC are 0.25 for age 0-4, 0.4 for 5-9 and 0.6 for 10-14. The incorporation of these weights reflects the effect of age structural changes induced by fertility variations upon the level of aggregate consumption.

Government Expenditure Function

(21) $$G_t = -11960 + \underset{(254.9)}{372.04}\, \ln Y_t + \underset{(669.2)}{863.1}\, \ln TP_t + \underset{(67.2)}{182.4}\, T4 + \underset{(51.6)}{791.7}\, T5$$

$$D - W = 1.741 \; ; \; R^2 = 0.935$$

This specified equation relates government spending (which is assumed to be all consumption) to the level of GDP (Y) and total population size (TP). Since the Meiji Government experienced two major wars during the estimation period, we have included dummy variables, T4 and T5, to capture irregularities of the pattern of government spending. T4 is defined to represent the effect of the Sino-Japanese

War on Government outlays (T4 = 1 for 1894 and 1895) and T5, that of the Russo-Japanese War (T5 = 1 for 1904, 1905 and 1906).

Export Function

$$(22)\quad X_t = -\,826.32 + \underset{(577.3)}{794.67}\,(Y_t^n/1000) - \underset{(144.0)}{237.57}\,(Y_t^n/1000)^2 + \underset{(11.5)}{26.023}\,(Y_t^n/1000)^3 - \underset{(21.5)}{75.34}\,(Y_t^n/1000 - 5.0)^3 \cdot D5 - \underset{(119.9)}{346.55}\,T6$$

$$D-W = 1.362\ ;\ R^2 = 0.976$$

Unlike most of the econometric models built for Japan, we did not include variables reflecting world business fluctuations and changes in relative prices. Instead, we have related exports (X) to the level of non-primary production in the form of a cubic spline function and the effect of World War I upon Japanese exports (T6). T6 takes a value of 1 in 1919 and 1920 and otherwise 0. The growth of Japanese exports was directly supported by the expansion of the non-primary production such as cotton and other textile products. In addition, the dummy variable, D5, takes value 1 if Y^n exceeds 5 billion yen.

It should be noted, however, that this cubic spline function yields a downward slope after Y^n reaches a value of 8.5 billion yen. In order to cope with this difficulty, the following equation has been utilized for Y^n above this value:

$$(22')\quad X_t = -\,519.6 + \underset{(0.06)}{0.2305}\,Y_t^n$$

$$D-W = 0.517\ ;\ R^2 = 0.620$$

Because the main focus of this study does not fall on the relationship between exports and economic development, we have confined ourselves to the simple specifications.

Import Function

$$(23)\quad M_t = -\,1749.3 + \underset{(0.02)}{0.041}\,EAC_t + \underset{(0.04)}{0.141}\,Y_t + \underset{(99.3)}{420.5}\,T2$$

$$D-W = 1.317\ ;\ R^2 = 0.956$$

An increase in total EAC is related to greater imports including foodstuffs. As discussed in the previous section, in the process of import substitution, the growth of the non-primary sector required a vast amount of foreign-made productive equipment from Western countries. This process is represented by the level of the gross domestic product. Furthermore, to avoid the spurious influence of the abrupt decline in exports after the Russo-Japanese War, we have incorporated a deletor variable T2, which takes a value of 1 for 1905 and otherwise 0. This import function completes the demand side of our model.

VI. The Performance of the Model

To examine the goodness of fit of these estimated equations, we have conducted a final test of the model.[5/] In the following graphs, observed values are shown by solid lines, and simulated values, by dotted lines.

Figure 2 presents observed and simulated values of primary output, non-primary output and total output, and clearly shows an extremely good fit. Despite considerable fluctuations observed with respect to primary output, the simulated values reflect the general upward trend of actual primary production. The simulated values of non-primary output and total GDP are also very close to those observed. In Figure 3, it is clearly illustrated that the variation in per capita GDP is well predicted by the simulation model.

Let us now look at simulated patterns of each of the two main inputs of the production functions: labor and capital. Figure 4 shows that the simulated value of the labor force participation rate is fairly well fitted to the actual one, except for a few years when per capita GDP declines due to irregularities of economic conditions induced by war influences. Together with the working age population, this predicted labor force participation rate is used to compute the total labor force. The simulated pattern of the total labor force is illustrated in Figure 5. The total labor force is further divided into the labor force for both primary and non-primary sectors, on the basis of the urban-rural migration function. The simulated results of the labor force for these sectors are plotted in Figure 5, which shows a high predictability of this model.

Figure 6 presents the observed and simulated patterns of capital stock. The pattern of the variation in capital stock for the non-primary sector has been well simulated, while the simulated value

Figure 2. Comparison of Actual and Simulated Values: Primary and Non-primary Output, and GDP

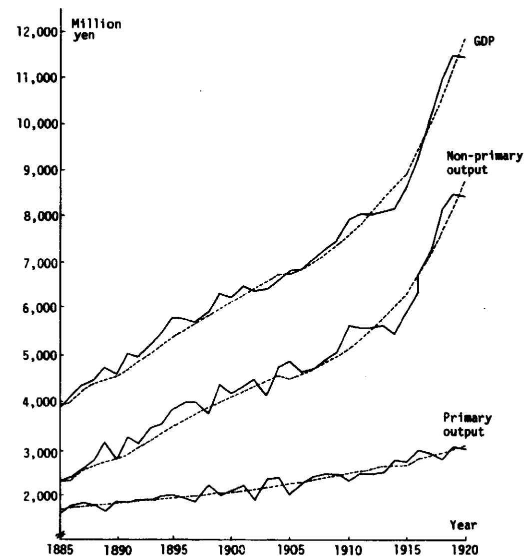


Figure 3. Pattern of Observed and Simulated Per Capita GDP

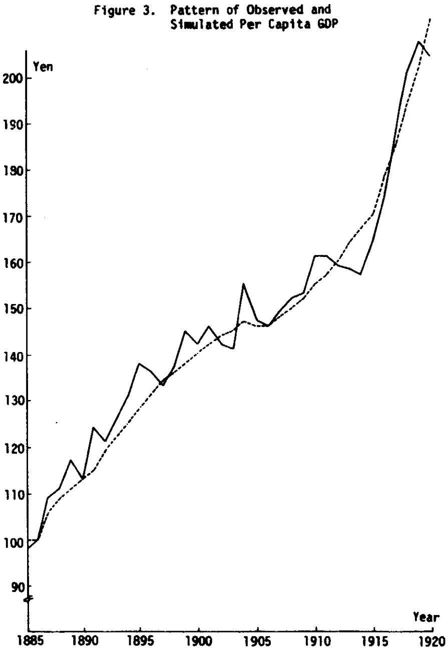


Figure 4. Actual and Simulated Values of the Labor Force Participation Rate

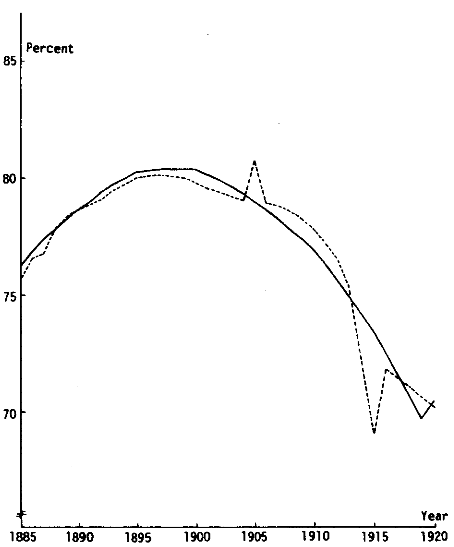


Figure 5. Actual and Simulated Values of the Labor Force

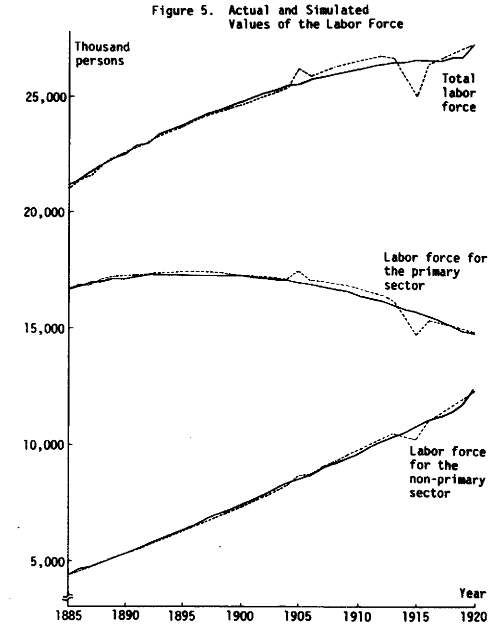


Figure 6. Actual and Observed Values of Capital Stock for Primary and Non-primary Sectors

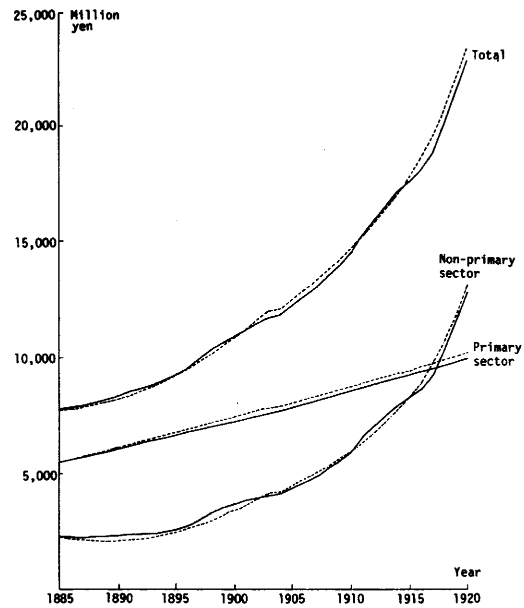


Figure 7. Actual and Simulated Values of Savings

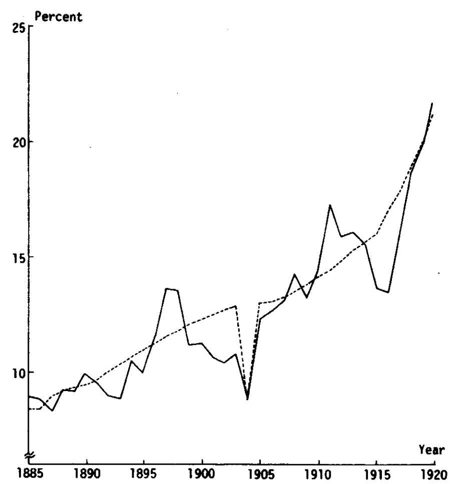


Figure 8. Actual and Observed Values of the Savings Allocation Rate

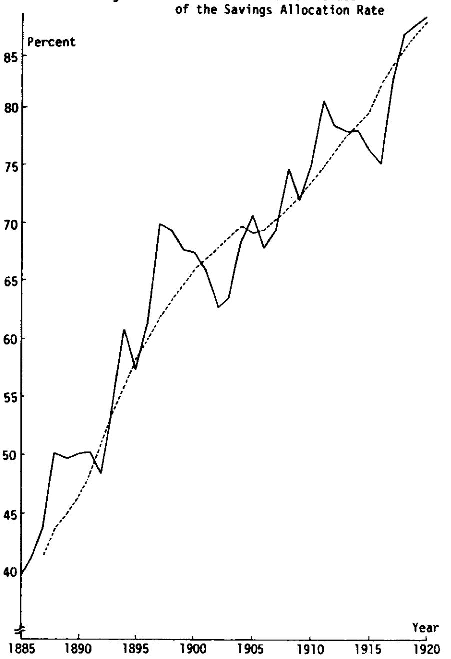


Figure 9. Actual and Simulated Values of Investment

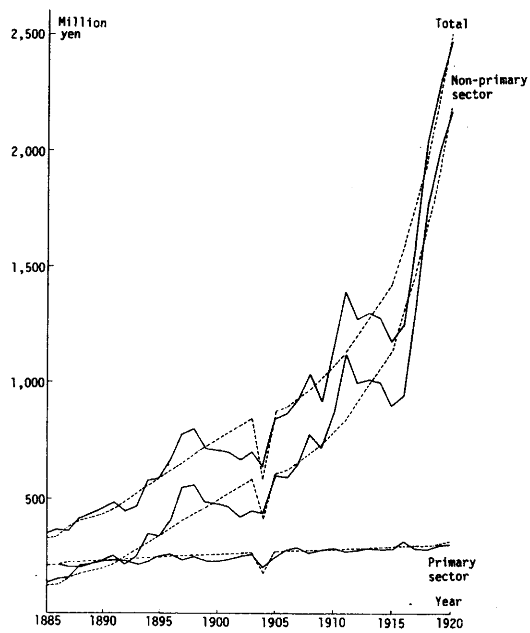


Figure 10. Actual and Simulated Values of Depreciation

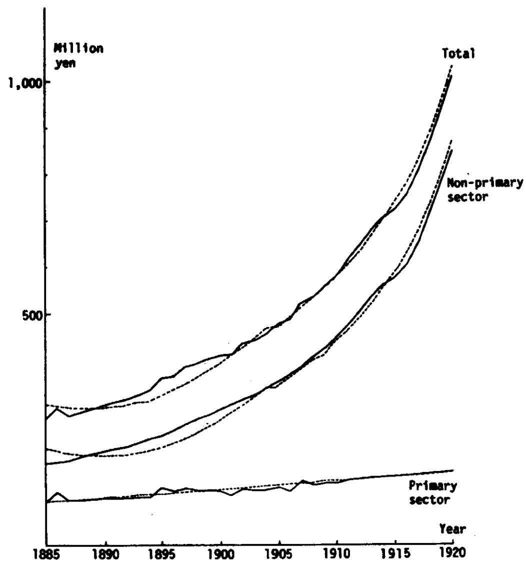


Figure 11. Actual and Simulated Values of Consumption

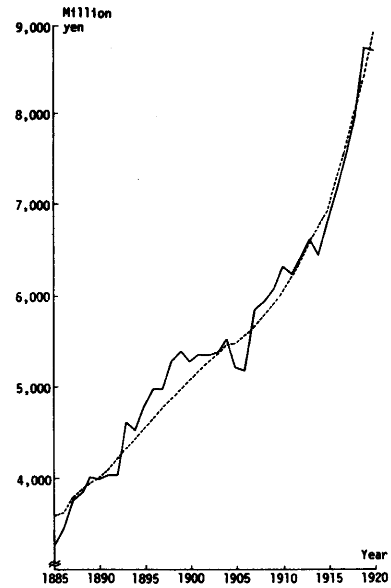


Figure 12. Actual and Simulated Values of Government Spending

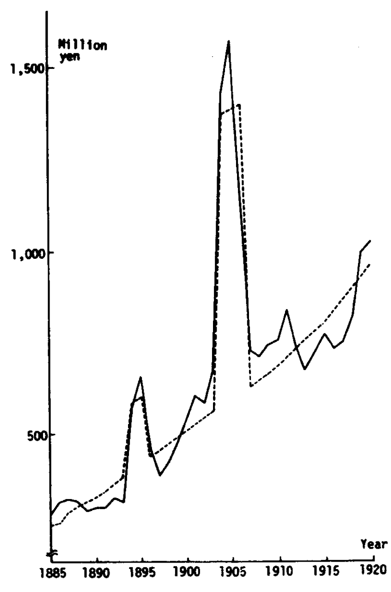


Figure 13. Actual and Simulated Values of Exports

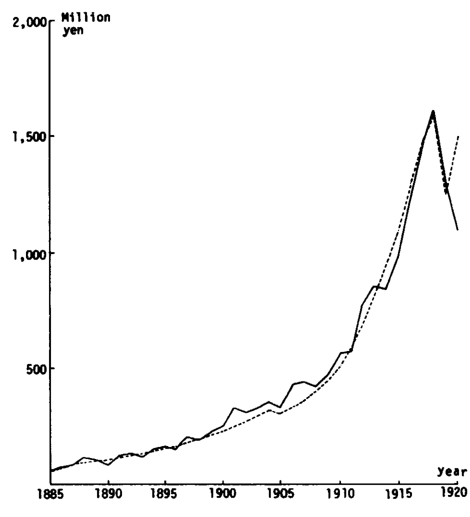
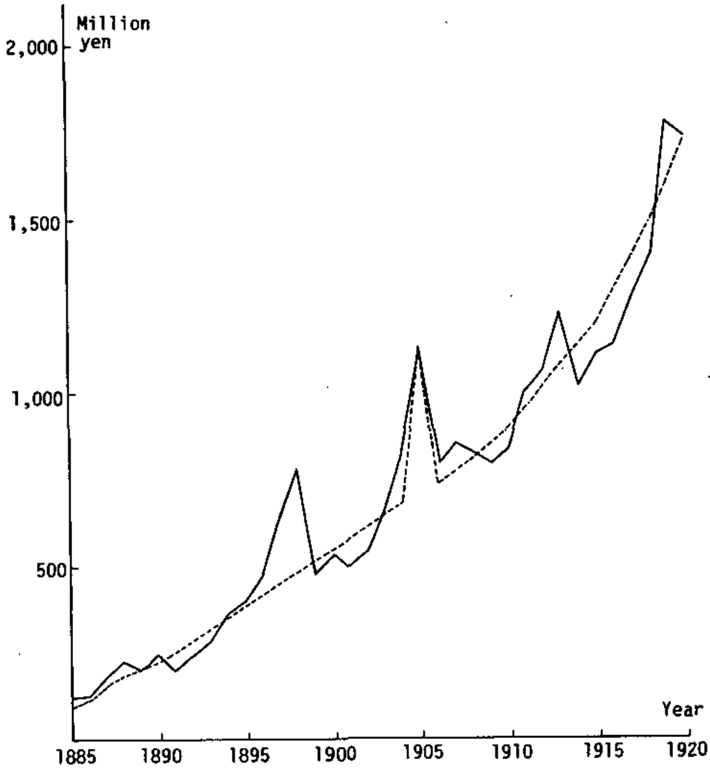


Figure 14. Actual and Simulated Values of Imports



of capital stock for the primary sector slightly exceeds observed levels. In connection with the variation in capital stock for each sector, the predictability of gross national savings and sectoral investment as well as depreciation should be evaluated. Let us first look at savings. Figure 7 indicates that the simulated pattern of savings appears to capture a general upward trend in actual savings during the period under study. On the basis of the savings allocation function, savings are allocated to the two production sectors in the form of sectoral investment. Figure 8 presents a reasonably good fit for this function. Furthermore, Figures 9 and 10 show accurately simulated values of sectoral investment and depreciation. From these plotted results, one may conclude that this model provides a sound base for analyzing the overall mechanism of the production side of Meiji Japan.

Apart from the production side, let us now assess the simulated value for each component of aggregate demand. Figures 11, 12, 13 and 14 illustrate both observed and simulated patterns of personal consumption, government spending, export, and import functions, respectively. Except for personal consumption, each demand component shows considerable deviations between observed and simulated values. The chief source of these discrepancies is attributable to external changes and military influences. Nevertheless, the overall performance of this model in predicting demand is reasonably satisfactory.

VII. Demographic Aspects of Development

In the absence of reliable data on important demographic parameters like total fertility rates, population growth during the Meiji period was treated as an entirely exogenous component of our model. Consequently, the simulations represent the impact of whatever changes in fertility and mortality did, in fact, occur, but we have no way to assess the impact of demographic change as a seperate element in Meiji economic development.

Partly to remedy this deficiency, and partly to gain additional insight into the role of demographic elements in the developing countries of present-day Asia, we have made a series of additional experiments in which population growth is no longer treated as an exogenous factor during the Meiji period, but is made an endogenous component of the model.

Since the absence of data makes it impossible to derive the necessary equations from the Meiji period, the following procedure was employed. Equations relating total fertility rate (TFR), mean age at child-bearing (MACB), and life expectancy at birth (e_0) were fitted to data drawn from fourteen developing countries in Asia today. From these, age-specific fertility and mortality rates can be derived as will be shown, and the resulting population growth can be generated endogenously. When these equations are inserted in the model in place of the exogenously given population growth, simulation over the Meiji period shows how the Meiji economy would have developed had it been subject to the demographic relationships found in present-day developing Asian countries instead of those that actually governed Meiji development. Comparison with the actual development of Meiji Japan then gives us an important clue as to how demographic factors affected the course of Meiji development.

For purposes of comparison, four cases are analyzed.

CASE I: Both birth and death rates are given from the actually observed data during 1885-1920 in Japan. (This case corresponds to the final test of the model.)

CASE II: Both fertility and mortality rates are derived from the functional relationships estimated from the intercountry data available among contemporary developing countries in Asia.

CASE III: The fertility rate is computed from the fertility function estimated from developing countries in Asia, while the death rate is given from the observed data of Meiji Japan.

CASE IV: Mortality is derived from the mortality function estimated from developing countries in Asia, and the birth rate is exogenously given on the basis of the experience of Meiji Japan.[6/]

The derivation of fertility and mortality functions reflecting the demographic situation in contemporary developing countries in Asia deserves some explanation. For the fertility function, we have selected fourteen developing countries in Asia and have compiled the data on per capita GDP, and the total fertility rate and mean age at child-bearing circa 1970.[7/] For these developing countries, we have also collected the data on the mean expectation of life at birth around 1970.

The Brass fertility estimation has been employed to compute age-specific fertility rates (ASFRs). One of the principal inputs required by this method is a value of mean age at child-bearing (MACB). Drawing upon a set of intercountry data, we have related MACBs to variations in per capita GDP (Y/TP) as follows:

$$(24)\quad MACB_t = 29.192 - \underset{(0.0005)}{0.000899}\ (Y_t/TP_t)$$

$$R^2 = 0.194$$

The main reason that the explanatory power of this estimated equation is fairly low, is that the variation of MACBs for these developing countries is relatively limited with respect to that of per capita GDP. Since MACB is nearly constant, errors arising from this estimation are small.

Besides MACBs, the Brass fertility estimation requires a value for the total fertility rate, (TFR). Like the MACB function, the variation in TFR is related to that in per capita GDP, as shown below:

$$(25)\ \ln(TFR - 3000) = \underset{(0.0008)}{8.334 - 0.00625}\ (Y_t/TP_t)$$

$$R^2 = 0.838$$

Utilizing these estimated values, we can estimate ASFRs by the following equation developed by W. Brass (1968):

$$(26)\ ASFR_{a,t} = [TFR/99826.75]\,[0.25\,(MACB_t + 14.8 - a)^4 - 11\,(MACB_t + 14.8 - a)^3 - 0.25\,(MACB_t + 19.8 - a)^4 + 11\,(MACB_t + 19.8 - a)^3]$$

The mortality values have been calculated via the following two steps. The first step was to estimate the functional relationship between life expectancy at birth (e_0) and per capita GDP. The estimation has been conducted for both sexes, with the data on the fourteen developing countries in Asia.8/ The estimated result can be shown as follows:

$$(27)\ e_0\ (\text{male}) = 9.98 + \underset{(1.54)}{9.82}\ \ln(Y_t/TP_t)$$

$$R^2 = 0.771$$

$$(28)\ e_0\ (\text{female}) = 4.25 + \underset{(1.90)}{11.65}\ \ln(Y_t/TP_t)$$

$$R^2 = 0.757$$

The estimated values obtained from these equations have been used to compute the value of L_x from the west levels of the Coale-Demeny regional model life tables (1966). A list of the estimated equations is attached to Appendix B.

Let us now analyze the results of these four simulation cases. Table 2 summarizes the changes in selected variables in the simulation experiments. In this table, CASE I provides a base for highlighting the difference in key variables between actual and counterfactual population growth patterns.

CASE II dismally reflects both fertility and mortality change being observed in the contemporary developing countries in Asia. This result is caused by pronounced differences in the demographic mecha-

Table 2. Simulated Values of Selected Variables for Four Different Cases

Year	TP (1,000 persons)	Y (million yen)	Y^n/Y	Y (1,000 persons)	N^n/N	K (million yen)	K^n/K	SR (percent)
				CASE I				
1886	39911.00	3960.09	0.574	21392.02	0.213	7792.90	0.270	8.4
1890	41018.99	4548.29	0.605	22573.54	0.235	8222.96	0.254	9.5
1895	42470.99	5365.12	0.643	23692.79	0.265	9269.01	0.267	11.0
1900	44392.99	6140.65	0.667	24583.19	0.297	10892.51	0.314	12.3
1905	46825.00	6741.34	0.667	26159.91	0.332	12555.16	0.357	13.0
1910	49637.00	7582.81	0.676	26481.98	0.369	14755.83	0.405	14.1
1915	52949.00	8932.79	0.707	24951.01	0.410	17787.98	0.466	16.0
1920	55962.99	11843.81	0.742	27171.66	0.453	23391.03	0.563	21.1
				CASE II				
1886	40114.54	3922.84	0.571	21556.86	0.207	7831.56	0.281	8.3
1890	43592.95	4377.70	0.590	22659.79	0.229	8093.05	0.240	8.7
1895	48527.18	4679.23	0.590	23860.91	0.259	8617.86	0.202	8.5
1900	54036.89	4434.01	0.528	25868.69	0.290	9021.67	0.160	7.4
1905	60529.60	3811.27	0.410	26755.43	0.324	8933.72	0.110	3.7
1910	68498.31	3376.24	0.271	27909.94	0.361	8717.54	0.064	5.2
1915	78054.25	3240.45	0.145	30120.86	0.401	8463.19	0.027	4.8
1920	89079.56	3286.48	0.023	33504.78	0.444	8250.49	0.002	4.6

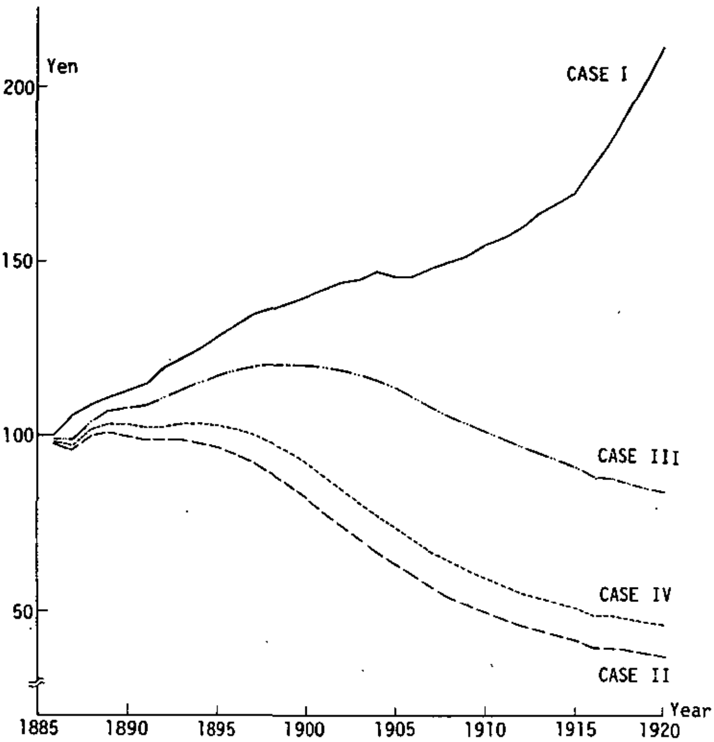
Table 2. (Continued)

Year	TP	Y	Y^n/Y	N	N^n/N	K	K^n/K	SR
				CASE III				
1886	39563.94	3916.33	0.5718	21450.99	0.2075	7833.37	0.2812	8.4
1890	40839.90	4411.75	0.5952	22445.12	0.2294	8143.50	0.2482	9.2
1895	42889.13	5021.78	0.6214	23551.11	0.2587	8940.03	0.2390	10.1
1900	45324.68	5466.38	0.6230	25176.61	0.2903	10063.85	0.2508	10.5
1905	48226.87	5519.49	0.5929	26492.39	0.3245	10864.09	0.2453	6.3
1910	51782.13	5272.74	0.5300	27468.79	0.3617	11474.83	0.2197	8.9
1915	56377.11	5176.29	0.4645	28526.57	0.4012	11825.09	0.1831	8.1
1920	61709.50	5196.93	0.3906	30167.05	0.4442	12077.51	0.1458	7.5
				CASE IV				
1886	39957.82	3923.31	0.571	21564.59	0.207	7832.01	0.281	8.3
1890	42809.31	4401.52	0.591	22806.59	0.229	8106.40	0.243	8.8
1895	46859.92	4807.14	0.598	24257.62	0.259	8703.56	0.212	8.9
1900	51290.62	4708.94	0.552	26204.38	0.290	9262.52	0.181	8.0
1905	56416.81	4132.86	0.453	26924.23	0.324	9303.14	0.134	4.0
1910	61766.54	3645.59	0.326	27594.41	0.361	9165.00	0.087	5.7
1915	68382.63	3457.30	0.208	29073.19	0.401	8950.74	0.048	5.2
1920	75089.44	3457.99	0.098	31157.82	0.444	8762.73	0.017	5.0

nism between Meiji Japan and these developing countries. If Meiji Japan had been subject to the fertility function currently found in these developing countries, it would have experienced a higher fertility rate than it did. Moreover, had the mortality mechanism of these countries existed in Meiji Japan, the Meiji mortality level would have been substantially lower. Because of its higher fertility and lower mortality, CASE II yields enormous population growth over the simulation period. As compared with CASE I, the population for CASE II is 21.7 percent larger in 1900, and 59.2 percent larger in 1920. Although lower mortality produces a larger labor force from the first year of the simulation period, faster population growth adversely affects growth of GDP and per capita GDP. As shown in Figure 15, per capita GDP for CASE II falls to 40 yen by 1920, as opposed to growth to 212 yen for CASE I. The decline in per capita GDP depresses the saving rate, and works against the accumulation of capital. Consequently, although both GDP and capital stock increase up to the turn of the century, they decline considerably for the rest of the simulation period. It should be also noted that as one of the side effects of such rapid population growth, the flow of capital into the non-primary sector is severely limited, thus hindering the process of industrialization.

CASE III is a reflection of the mortality rate actually observed during the Meiji period but combined with the fertility rate currently observed in the developing countries in Asia. At the level of economic development of Meiji Japan, the fertility mechanism in the developing countries yields a population larger than that of CASE I, but considerably smaller than that of CASE II. In 1900 the former is approximately 16 percent smaller than the latter, and in 1920 the difference becomes more than 30 percent. Although CASE III involves substantial population growth, the economy still sustains a driving force to increase GDP up to the turn of the century, consequently raising per capita GDP, as indicated in Figure 15. The growth of per capita GDP contributes to that of the savings rate, which in turn, leads to the expansion of capital stock. Towards the end of the 19th century, however, increasing pressure of higher population growth results in a continuous decline in per capita GDP. Subsequently, reduced per capita GDP leads to a decreases in the saving rate and in the proportion of capital to be allocated to the non-primary sector, thus retarding the process

Figure 15. Changes in Per Capita GDP
in Four Different Cases



of industrialization. The share of non-primary output in terms of GDP expands from 57 percent in 1886 to 62 percent in 1900, but after that it shrinks continuously to 39 percent in 1920. Per capita GDP for the final year of simulation is 84 yen, which equals 40 percent of per capita GDP for CASE I in the corresponding year.

CASE IV, which assumes the mortality mechanism of the developing countries and the fertility rate actually observed in Meiji Japan, shows results quite close to those of CASE II. The population of CASE IV grows at a rate considerably faster than that for CASE I or CASE III and slightly slower than that for CASE II. Per capita GDP slightly rises in the early years of simulation, but thereafter declines continuously to 46 yen in 1920, which is only 22 percent of per capita GDP for CASE I in the same year. The saving rate changes in a similar pattern. The share of capital stock alloted to the non-primary sector decreases from 28 percent in 1886 to only 1.7 percent in 1920. Although both GDP and the proportion of non-primary output to GDP increase in the early part of simulation, they decline drastically after 1895.

These simulated results clearly suggest that population growth observed in contemporary developing countries in Asia is vastly different from that observed during the Meiji period in Japan. Had the Meiji economy faced the same population growth pattern as in modern Asian developing countries, the Meiji economy would have been unable to follow the sustained growth path it experienced.

Secondly, contemporary developing Asian countries differ from Meiji Japan more profoundly in mortality than in fertility. This may reflect that the mortality decline in Meiji Japan was closely linked to its economic development, while that in the contemporary developing countries in Asia has been achieved by imported medical technologies and public health measures from advanced countries.

Finally, in contrast to the conclusion reached by Kelley and Williamson (1974), our simulation findings indicate that Japanese demographic conditions, particularly mortality changes during the Meiji period, which are unusual by contemporary standards, played a vital role in facilitating and initiating Japanese economic growth.

In the above simulation exercises, we have analyzed the effect of alternative demographic conditions upon the Meiji economy. Let us now take a step further, and examine the saving rates that would be required in each case to achieve the same per capita GDP as actually experienced in Meiji economic progress. The computational results are shown in Table 3. Before we interpret these results, two remarks should be made. First, CASE I, indicating the actual change in the saving rate observed in Meiji Japan, provides a base for measuring required additional saving rates under the three alternative population growth paths. Second, because the computed required saving rates fluctuate considerably in each year, we have smoothed them out by taking the average value of saving rates in each 5-year interval, as shown in Table 3, in order to see a general trend of the required saving rates for each population growth pattern.

CASE II, which yields the most dreary economic development process, requires the highest savings in early years. In the first five years, for instance, it requires a rate 2.45 times as high as CASE I. Although the required saving rate for CASE II decreases considerably in the early 1900s, it increases markedly towards the end of the

Table 3. Required Saving Rates
for
Achieving Meiji Development

(unit: percent)

Year	Demographic Condition			
	CASE I	CASE II	CASE III	CASE IV
1886 - 1890	9.07	22.24	11.89	18.27
1891 - 1895	10.34	20.71	10.99	17.26
1896 - 1900	11.78	17.31	11.38	16.85
1901 - 1905	11.91	19.26	12.17	19.41
1906 - 1910	13.55	22.49	13.36	21.57
1911 - 1915	15.20	23.51	14.27	24.05
1916 - 1919	18.35	28.14	17.80	28.87

simulation period. By and large, CASE IV follows a similar changing pattern, but as opposed to CASE II, CASE IV requires noticeably lower saving rates in the first half of the simulation period and somewhat higher saving rates in the latter half. Both CASE II and CASE IV need much higher saving rates than CASE I throughout the simulation period.

In contrast, CASE III which shows a pattern conspicuously different from these two cases, requires substantially lower saving rates. In fact, CASE III is quite comparable to CASE I. Although CASE III needs saving rates slightly higher than CASE I in the first decade of simulation, in the 1900s, the former requires lower saving rates than CASE I. It should be stressed that such initially required saving rates for CASE III fall within the range of saving rates observed in a few selected developing countries in Asia, as indicated in Table 4. This suggests that if population growth were slowed to match that of Meiji Japan, the contemporary developing countries in Asia could place themselves on an equally rapid economic development path.

Table 4. Saving Rates in Some Selected Developing Countries in Asia

(unit: percent)

Year	Republic of Korea	Indonesia	Thailand
1965	8.75	8.30	21.95
1970	17.59	12.27	25.65
1975	18.90	16.67	27.42

Source: Bank of Korea, National Account of Korea, various issues; International Monetary Fund, Financial Statistics, various issues.

VIII. Concluding Remarks

The two-sector model which we have developed incorporates demographic variables more explicitly and elaborately than any other model previously formulated for Meiji Japan. Our model appears to satisfactorily account for the dualistic process of Japanese modern development.

One of the major findings of our simulation work is that the demographic mechanism in the present developing countries in Asia is enormously different from that of Meiji Japan. For this reason, one may say that the demographic pattern observed during the Meiji period is unusual by contemporary standards. One should note, however, that the main source of this demographic uniqueness lies in the slow decline in mortality. While Meiji Japan experienced a slow sustained decline in mortality in line with its economic development, the contemporary developing region of Asia has been undergoing sharp mortality reduction through medical technologies and public health measures imported from advanced countries. Only if these countries can balance this drop with more rapidly declining fertility will they be in a position to achieve economic development comparable to that of Meiji Japan.

Insofar as fertility is concerned, both Meiji Japan and the contemporary developing nations in Asia seem to have a considerable degree of compatibility and similarity. In this context, further analyses on the fertility behavior of Japan in its early stages of development might yield findings both useful and relevant to these developing nations in Asia.

IX. Acknowledgements

The authors are grateful to Andrew Mason for his useful comments on an earlier version of this paper. Thanks are also due to Toru Ishii for his competent programming assistance.

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Appendix A

Saving Rate Function

$$(4a)\quad \ln [(0.4 - SR_t)/SR_t] = 2.567 - \underset{(0.734)}{9.753} (Y_t/EAC_t) + \underset{(0.157)}{0.565} T2$$

$$D - W = 0.990 ; R^2 = 0.849$$

Labor Force Participation Rate Function

$$(7a)\quad V_t = 0.6386 - \underset{(0.0001)}{0.00045} CW_t + \underset{(0.0002)}{0.00099} EDUC_t$$

$$+ [\underset{(1.63)}{6.854} (Y_{t-1}/TP_{t-1}) - \underset{(19.4)}{49.63} (Y_{t-1}/TP_{t-1})^2$$

$$+ \underset{(69.9)}{112.57} (Y_{t-1}/TP_{t-1})^3 - \underset{(1191.2)}{1434.6} (Y_{t-1}/TP_{t-1} - 0.14)^3 \cdot$$

$$D1] \cdot D2 - \underset{(0.03)}{1.3728} (1 - D2) \ln (Y_{t-1}/TP_{t-1})$$

$$- \underset{(0.005)}{0.0194} T2 + \underset{(0.005)}{0.0121} T3$$

$$D - W = 1.275 ; R^2 = 0.978$$

Consumption Function

$$(20a)\quad C_t = 138.28 + \underset{(0.04)}{0.0334} EAC_t + \underset{(0.07)}{0.609} Y_t$$

$$D - W = 0.964 ; R^2 = 0.985$$

Government Expenditure Function

$$(21a)\quad G_t = - 12093 + \underset{(260.0)}{379.7} \ln Y_t + \underset{(704.0)}{868.3} \ln TP_t + \underset{(67.0)}{179.9} T4 + \underset{(51.7)}{790.6} T5$$

$$D - W = 1.733 ; R^2 = 0.935$$

Import Function

$$(23a)\quad M_t = - 1779.7 + \underset{(0.02)}{0.041} EAC_t + \underset{(0.04)}{0.143} Y_t + \underset{(99.5)}{415.7} T2$$

$$D - W = 1.320 ; R^2 = 0.956$$

Appendix B

The following equations relating e_0 to the value of L_x for the model west of the Coale-Demeny regional model life tables have been estimated for every 5-year age group for both sexes.

Males:

$${}_1L_0 = 10.68 + \underset{(0.003)}{0.1899} \ln e_0 \qquad R^2 = 0.994$$

$${}_4L_1 = 10.88 + \underset{(0.007)}{0.468} \ln e_0 \qquad R^2 = 0.995$$

$$L_5 = 10.63 + \underset{(0.009)}{0.580} \ln e_0 \qquad R^2 = 0.994$$

$$L_{10} = 10.41 + \underset{(0.01)}{0.631} \ln e_0 \qquad R^2 = 0.995$$

$$L_{15} = 10.19 + \underset{(0.01)}{0.681} \ln e_0 \qquad R^2 = 0.995$$

$$L_{20} = 9.92 + \underset{(0.01)}{0.745} \ln e_0 \qquad R^2 = 0.996$$

$$L_{25} = 9.59 + \underset{(0.01)}{0.819} \ln e_0 \qquad R^2 = 0.996$$

$$L_{30} = 9.23 + \underset{(0.01)}{0.903} \ln e_0 \qquad R^2 = 0.996$$

$$L_{35} = 8.82 + \underset{(0.01)}{0.996} \ln e_0 \qquad R^2 = 0.997$$

Females:

$${}_1L_0 = 10.55 + \underset{(0.003)}{0.223} \ln e_0 \qquad R^2 = 0.996$$

$${}_4L_1 = 10.73 + \underset{(0.008)}{0.508} \ln e_0 \qquad R^2 = 0.995$$

$$L_5 = 10.52 + \underset{(0.01)}{0.612} \ln e_0 \qquad R^2 = 0.995$$

$$L_{10} = 10.33 + \underset{(0.01)}{0.654} \ln e_0 \qquad R^2 = 0.995$$

$$L_{15} = 10.16 + \underset{(0.01)}{0.695} \ln e_0 \qquad R^2 = 0.995$$

$$L_{20} = 9.92 + \underset{(0.01)}{0.751} \ln e_0 \qquad R^2 = 0.996$$

$$L_{25} = 9.61 + \underset{(0.01)}{0.822} \ln e_0 \qquad R^2 = 0.996$$

$$L_{30} = 9.25 + \underset{(0.01)}{0.904} \ln e_0 \qquad R^2 = 0.997$$

$$L_{35} = 8.84 + \underset{(0.01)}{0.999} \ln e_0 \qquad R^2 = 0.997$$

$$L_{40} = 8.39 + \underset{(0.01)}{1.094} \ln e_0$$

$$R^2 = 0.997$$

$$L_{45} = 7.95 + \underset{(0.01)}{1.195} \ln e_0$$

$$R^2 = 0.997$$

$$L_{50} = 7.44 + \underset{(0.01)}{1.309} \ln e_0$$

$$R^2 = 0.998$$

$$L_{55} = 6.80 + \underset{(0.01)}{1.45} \ln e_0$$

$$R^2 = 0.998$$

$$L_{60} = 5.93 + \underset{(0.01)}{1.638} \ln e_0$$

$$R^2 = 0.998$$

$$L_{65} = 4.76 + \underset{(0.02)}{1.889} \ln e_0$$

$$R^2 = 0.998$$

$$L_{70} = 3.22 + \underset{(0.02)}{2.22} \ln e_0$$

$$R^2 = 0.998$$

$$L_{75} = 1.12 + \underset{(0.03)}{2.64} \ln e_0$$

$$R^2 = 0.998$$

$$L_{80} = -2.28 + \underset{(0.02)}{3.42} \ln e_0$$

$$R^2 = 0.999$$

$$L_{40} = 8.36 + \underset{(0.01)}{1.112} \ln e_0$$

$$R^2 = 0.997$$

$$L_{45} = 7.80 + \underset{(0.01)}{1.24} \ln e_0$$

$$R^2 = 0.998$$

$$L_{50} = 7.14 + \underset{(0.01)}{1.39} \ln e_0$$

$$R^2 = 0.998$$

$$L_{55} = 6.37 + \underset{(0.01)}{1.56} \ln e_0$$

$$R^2 = 0.998$$

$$L_{60} = 5.42 + \underset{(0.01)}{1.76} \ln e_0$$

$$R^2 = 0.999$$

$$L_{65} = 4.19 + \underset{(0.02)}{2.019} \ln e_0$$

$$R^2 = 0.999$$

$$L_{70} = 2.62 + \underset{(0.02)}{2.34} \ln e_0$$

$$R^2 = 0.999$$

$$L_{75} = 0.511 + \underset{(0.02)}{2.76} \ln e_0$$

$$R^2 = 0.998$$

$$L_{80} = -2.66 + \underset{(0.03)}{3.46} \ln e_0$$

$$R^2 = 0.999$$

Notes

1/ Rostow (1960) insists that Japan is one of the few countries in which economic take-offs occurred with virtually no capital imports.

2/ Davis (1963) explains the migratory movement of surplus labor by his theory of multiphasic response.

3/ These expenditures, which were basically directed for unproductive purposes, might be regarded as a flow in Japan's prompt industrializing process (Oshima, 1965).

4/ It should be also noted that because Kelley and Williamson assigned hypothetical value 100 to primary output as well as each of these productive inputs as initial conditions, one needs numerical adjustments to relate the predicted value for Y^P and the observed one.

5/ It should be stressed that the equations have been estimated not as a system as a whole but independently of each other, and appropriate numerical adjustments are needed to make the model workable. In the process of the final test, therefore, we have adjusted the intercept of the saving rate function, so as to improve the performance of the model. Because the original intercept (2.601) in equation (4) yields somewhat lower values of economic indicators such as per capita GDP, the intercept has been changed to 2.542.

6/ Due to the absence of any reliable data on the number of births to women of each age group over the time period under study, we have attempted to estimate age-specific fertility rates for the simulation exercise of CASE IV in the following manner. Because age at marriage rose substantially in Japan prior to World War II, due to improved educational levels, age-specific fertility rates for young age groups lowered. Taking into account this demographic phenomenon, we have related age-specific fertility rates for age groups 15-19 and 20-24, to the percentage of the enrollment of both males and females at the secondary level (ENR), drawing upon the data for the period of 1925-1937. The estimated equations can be expressed as follows:

$$ASFR\ (15\text{-}19)_t = 0.071 - \underset{(0.0002)}{0.00638}\ ENR_t$$

$$D - W = 2.530\ ;\ R^2 = 0.997$$

$$ASFR\ (20\text{-}24)_t = 0.307 - \underset{(0.002)}{0.0175}\ ENR_t$$

$$D - W = 2.094\ ;\ R^2 = 0.994$$

For age groups other than these two groups, the general fertility rates have been computed from both Okazaki and Yasukawa estimates for the period of 1885-1920, which in turn, have been checked against the post-censusal general fertility rates. Once they were matched against the observed values, then the fertility pattern of each year was used to estimate the age-specific fertility rates of other age groups, namely, 25-29, 30-34, 35-39, 40-44 and 45-49, by proportional statistical adjustments. We have employed these estimated values as approximate ones.

7/ These fourteen developing countries in Asia include Afghanistan, Bangladesh, Burma, Hong Kong, India, Indonesia, West Malaysia, Nepal, Pakistan, the Philippines, Republic of Korea, Singapore, Sri Lanka and Thailand. The data on per capita GDP are available in the World Bank publication (1980), and the values of both MACB and TFR are obtained from Palmore's estimates (1978).

8/ The data on life expectancy at birth have been gathered from the work conducted by Swanson et al (1977). The fourteen developing Asian countries included in this mortality estimation are the same with the case of the fertility estimation.

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