New Lessons on Population and Economic Change from the Japanese Meiji Experience

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ABSTRACT

To analyze the development process of Meiji Japan, several formal models have been developed. Among these models, those of Kelley and Williamson, and Ogawa and Suits provide contrasting views on the effect of population change upon economic development. In the first half of this paper, a theoretical explanation for the differences in the conclusions between these two models is given. In the second half, a new 'hybrid' model is formulated, by incorporating important features of both Kelley-Williamson and Ogawa-Suits models. In addition, a few historical counterfactual simulations are conducted to highlight the role of the 'model closure' adopted.

I. Introduction

Among the formal models developed to simulate the economic development of Meiji Japan, those of Kelley and Williamson (1974) and Ogawa and Suits (1982) provide contrasting views on the role of population in Japanese development over this crucial period of her economic history. The scope of the Kelley-Williamson study was far wider than the focus of this paper. In a small but important section of the book, however, Kelley and Williamson have concluded that "contemporary population pressure would have exerted a small effect on the Meiji economic development" (p.132). In contrast, Ogawa and Suits have arrived at very different conclusions: "had the Meiji economy faced the same population growth pattern as modern Asian developing countries, the Meiji economy would have been unable to follow the sustained path it did follow" (p.214). These historical speculations --or 'counterfactuals' as cliometricians prefer to call them--are not only of interest to students of Japanese economic history but also provide important policy insights for contemporary developing economies.

The differences in the conclusions drawn are all the more surprising given the similarities in the models used in the counterfactual experiments. Both models employ a dualistic approach to development; both use constant returns production functions, and both adopt a 'neoclassical' model closure. And yet the lessons drawn are startlingly different.

The first objective of this paper is to provide a theoretical explanation for these differences. This we do in Section II. In Section III, we develop a new 'hybrid' model of the Meiji period, a model which incorporates important features of both Kelley-Williamson and Ogawa-Suits studies. In Section IV, we report the results of the historical counterfactual simulations and highlight the role of the 'model closure' adopted. Finally, we summarize our findings in Section V.

II. Two Models of Population and Development

Our purpose in this section is to explain why theoretically one would expect the Kelley-Williamson and Ogawa-Suits models to reach their different conclusions. We begin with a presentation in a simplified schematic form of the structures of the two models, as illustrated in Figures 1 and 2. The key relationships of the Kelley-Williamson model may be appreciated by following Figure 1, guided by the following considerations:

(i) In any one period, aggregate capital and labor resources in the economy are fixed, although they change between periods as new investment and depreciation influence the former and labor growth affects the latter;

(ii) Profit maximizing behavior by firms, perfect competition in factor and goods markets, and factor full employment are assumed throughout. Moreover, factor supplies are perfectly mobile between sectors within any one solution period, so that factor prices (wages and the rental on capital) are equal in primary and industrial sectors.

(iii) Profit maximization, perfect competition and full employment determine factor inputs to the two sectors and thus sector outputs. Kelley and Williamson employ a Cobb-Douglas production function in the primary sector and a CES function in industry.

(iv) Wages and profits received by factors will accrue to households as income. Part of this income is saved, but the propensity to save out of labor income is assumed to be zero. Thus, the economy-wide savings rate will be higher, the lower is labor's share in output.

(v) Expenditures on industrial and primary goods are determined by a linear-expenditure system in which 'dualism in demand' is reflected in different marginal budget shares of incomes generated in the two sectors.

(vi) The general equilibrium character of the model is indicated by the condition (bottom left and right) that

Figure 1. Simplified Schematic Flow of Kelley-Williamson Model (Static Solution)

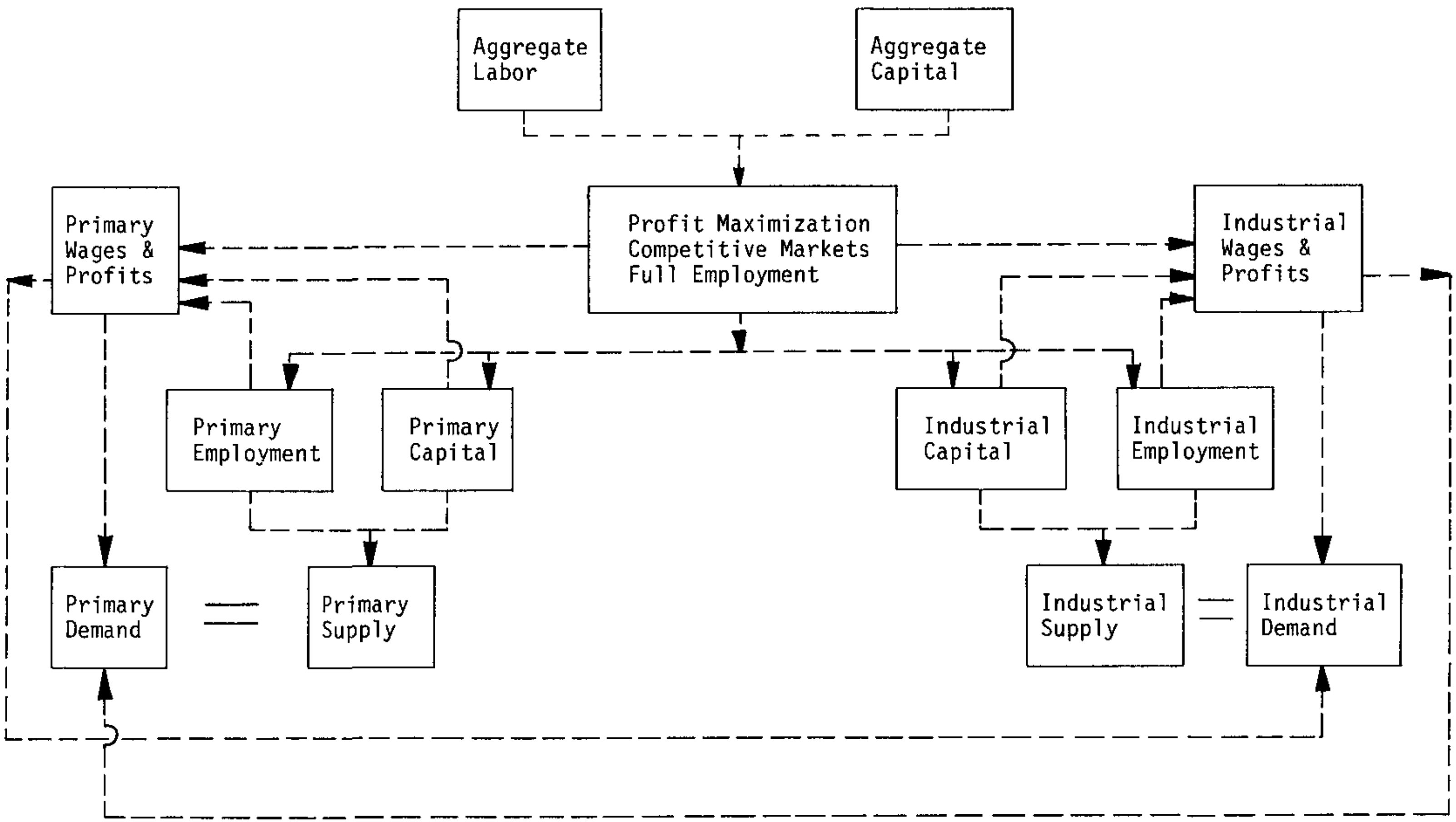
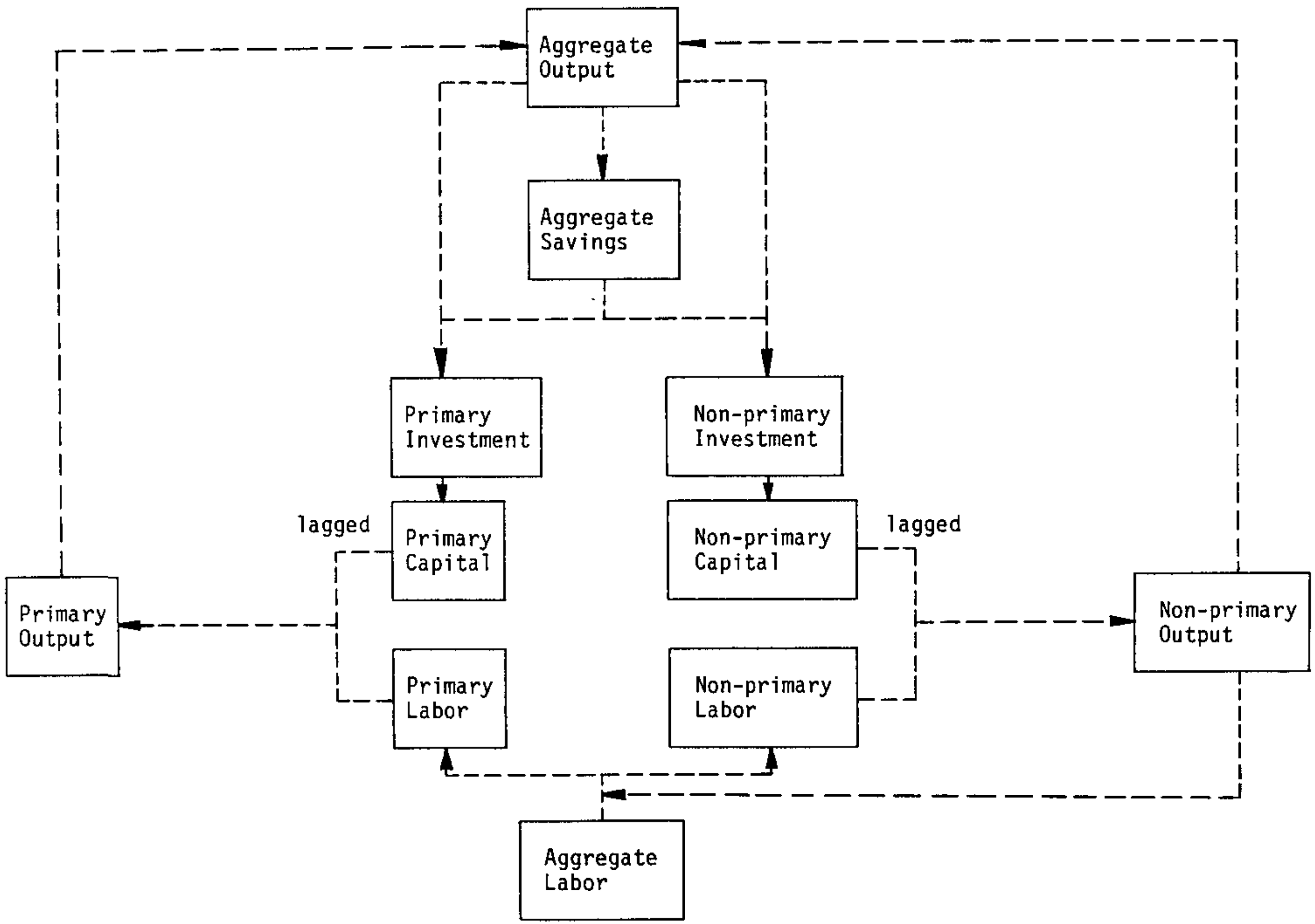


Figure 2. Simplified Schematic Flow of Ogawa-Suits Model (Static Solution)



demands and supplies be equal. A helpful way to appreciate the model structure (though not necessarily its solution method) is to note that if demand in any sector is greater than supply (at 'first pass'), the relative price of that sector is raised, attracting capital and labor to that sector and reducing demand (the Mashallian 'scissors').

In Figure 2, a similar schematic presentation is given for the Ogawa-Suits model. Again, the structure of the Ogawa-Suits model can best be appreciated by an examination of Figure 2, guided by the following remarks:

(i) Aggregate labor is allocated to the primary and secondary sectors by a rural-urban migration function. Labor and capital are not mobile between the sectors within the solution period.

(ii) Output is determined in the two sectors by a Cobb-Douglas function of current labor and lagged stocks of capital.

(iii) The economy wide savings rate is determined by aggregate output (in fact, output per adult equivalent), and once the savings rate is known, aggregate savings are computed.

(iv) Total savings are distributed to primary and industrial sectors in a manner which does not reflect differential profitability. Instead, it is assumed that at early stages of growth, the non-primary sectors attract a growing share of capital available.

(v) The primary and industrial labor markets are cleared separately. This means that wage differentials may persist between the sectors. Moreover, the rental rate on capital will also be different between the two sectors.

(vi) By lagging the capital stock in the production functions, Ogawa and Suits insure that the model is fully recursive.

In important respects, the models have similar features: they both employ constant returns production functions in a dualistic framework and they both assume that investment adjusts passively to equal savings (the so-called 'neoclassical closure'). Their contrasting conclusions on the effects of population on development must be attributed to their differences, which we now itemize.

First, Kelley and Williamson assume perfect factor mobility and full employment, so that factors prices are equalized across the sectors. It is unlikely that this difference will be crucial in the population counterfactual simulation. Indeed, in an earlier contribution, Kelley, Williamson and Cheetham (1972) allowed for labor immobility between the sectors and found that "the effect of variations in the 'natural' rates of population growth on output expansion, output per capita, the level of industrialization and urbanization is similar to that of the equilibrium model" (p. 282).

Secondly, Ogawa and Suits omit to specify the relative price required to ensure product market equilibrium. Indeed, the demand side has no role to play in sectoral allocation, only insofar as its effect is captured indirectly in the reduced form functions determining labor movement and investment shares.

Thirdly, Kelley and Williamson employ a CES production function in industry (with elasticity of substitution between capital and labour set at 0.8) whereas Ogawa and Suits maintain the Cobb-Douglas specification in both sectors.

Finally and, in our view, crucially, savings rates are determined very differently in the two models. In the Kelley-Williamson study the key determinant of the economy-wide savings rate is the distribution of income between capital and labor, since only capitalists save, whereas Ogawa and Suits assume that the savings rate depends on the level of GDP per adult equivalent.

Perhaps, of more importance than differences in economic framework is the contrasting treatment of demographic change. In the Kelley-Williamson model, the approach is simplistic: the alternative population scenario considered is simply one where the growth rate is tripled. The Ogawa-Suits approach is more elaborate, for they model the mean age of child- bearing, total and age-specific fertility, and life expectancy at birth. As a consequence, their historical counterfactuals can be more discriminating about the sources of population change.

The key differences in economic structure are easily indicated by a one-sector illustration of each model. The following analysis will suggest that the choice of production function specification and the nature of capital formation in the two models are key issues.

In a one-sector representation of the Kelley-Williamson model, we assume the CES production function adopted for KW's industrial sector, viz

$$Y = A \{\alpha_K K^{\frac{\sigma-1}{\sigma}} + (1 - \alpha_k) N^{\frac{\sigma-1}{\sigma}}\}^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where Y = aggregate output, K = capital stock, N = employment, α_k = the distribution parameter, A = a constant, and σ = the elasticity of substitution. This may be written as

$$Y = A \{(1 - \alpha_k) + \alpha_k k^{\frac{\sigma-1}{\sigma}}\}^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where $y \equiv Y/N$ --- labor productivity, and $k \equiv K/N$ --- capital/labor ratio. Given competitive markets and profits maximizing behavior, the share of labor is $A (1 - \alpha) y^{[(1 - \sigma)/\sigma]}$. In the Kelley-Williamson case, all labor income is consumed and a fraction, $\bar{c}$ of non labor income is consumed. The consumption function in these circumstances is:

$$C = (1 - \bar{c}) A (1 - \alpha_k) y^{\frac{1-\sigma}{\sigma}} Y + \bar{c} Y \tag{3}$$

where C is aggregate consumption.

Aggregate savings, S can be expressed as follows:

$$S = (1 - \bar{c}) [Y - A (1 - \alpha_k) y^{\frac{1-\sigma}{\sigma}} Y] \tag{4}$$

Again, this can be written in per worker terms as:

$$S = (1 - \bar{c}) [y - A (1 - \alpha_k) y^{\frac{1}{\sigma}}] \tag{5}$$

The sign of the derivative, $ds/dk = (\partial s/\partial y)/(\partial y/\partial k)$ depends on the sign of the derivative of S with respect to Y. This is easily seen as:

$$\frac{\partial s}{\partial y} = (1 - \bar{c}) \left[1 - \frac{A(1 - \alpha_k)\, y^{\frac{1-\sigma}{\sigma}}}{\sigma}\right] \qquad (6)$$

If $\sigma = 1$ (the Cobb-Douglas case), this derivative is always positive; savings per worker must rise as output per worker increases. For $\sigma < 1$, however, the sign is not known a priori. The smaller is σ, the more likely it is that savings will fall with output. Indeed, the derivative will be zero if

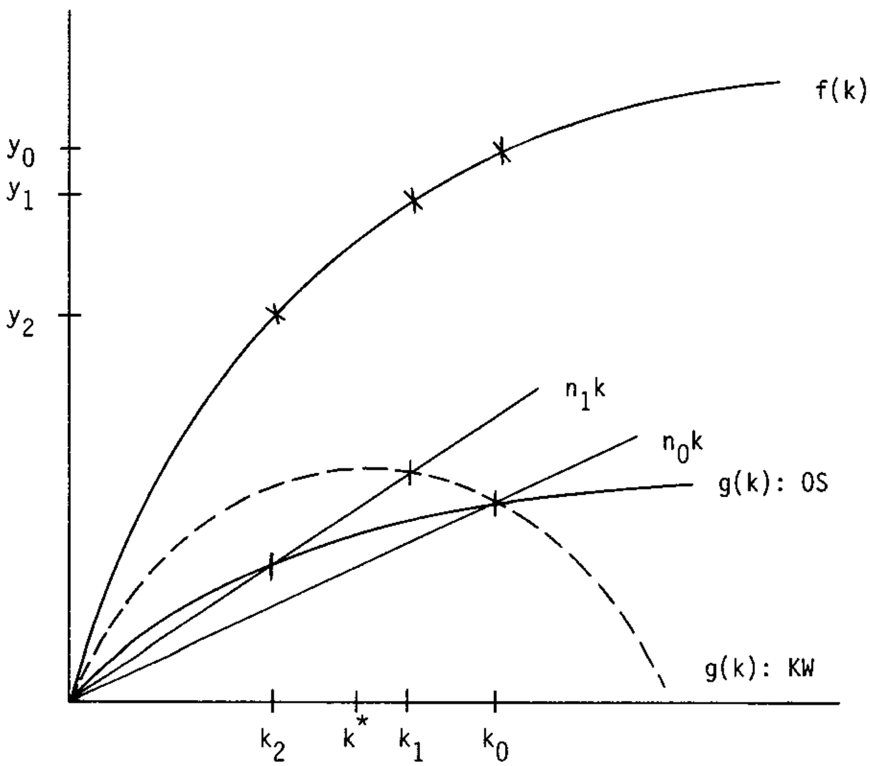
$$k^* = \left(\frac{(1 - \alpha\ )(1 - \sigma)}{\sigma\alpha_k}\right)^{\frac{\sigma - 1}{\sigma}} \qquad (7)$$

The importance of this is best appreciated with reference to Figure 3. The relationship between savings per worker and the capital/labor ratio is given by g(k): KW for the Kelley-Williamson case. This is equation (5) above with equation (2) substituted in place of y.[1/] The function f(k) is equation (2). Note that g(k) is a maximum at k^* with $\sigma < 1$ (the Kelley-Williamson case). Of course, the Kelley-Williamson model has two sectors and it is impossible to be sure where along g(k) their simulations concentrate. However, given the values adopted in the industrial sectors, we would expect $k^* = 2$ whereas the initial k for the industrial sectors is over 4. This suggests that the Meiji simulations may concentrate on the downward section of g(k).

The steady-state equilibrium occurs when the capital/labor ratio is constant, ie., when $nk = g(k)$, where n is labor growth. A rise in labor growth from n_0 to n_1 will lower k and y to k_1 and y_1, respectively. In this one sector model this result is inevitable; quantitative models only illuminate the dimensions of the effect--not its direction.

In the Ogawa-Suits model, the fact that the savings rate is an increasing function of output (and therefore k) implies $g'(k) > 0$ for all k, (and again stability requires that $g''(k) < 0$). The one-sector illustration of the model's savings function is shown diagramatically as g(k): OS in Figure 3. A similar increase in labor growth will have

Figure 3. Relationship between Savings Per Worker and the Capital / Labor Ratio



a more pronounced effect on y and k in the Ogawa-Suits case.

It follows then that the contrasting conclusions reached by Kelley and Williamson, and Ogawa and Suits, quoted in the introduction, may follow directly from their assumptions on production technology and savings behavior. Moreover, in developing a hybrid model of the Meiji period, the preceding sections highlight two key questions:

(i) Is the production technology adopted by Kelley and Williamson for the industrial sector appropriate? They support their choice of $\sigma < 1$ by reference to the impressionistic evidence presented by Watanabe (1968) and Odaka and Ishiwata (1972), together with more formal studies from other countries (eg. Nerlove (1967)). But they make no effort to test for non-unitary elasticity using Meiji time-series data.

(ii) Is the propensity to consume higher for workers than for capitalists? Kelley and Williamson present circumstantial evidence but conclude that "the relevant quantitative evidence from the Meiji period is as yet much too fragmentary for forming definite judgments on these issues" (p.56).

We address both these questions in the next section.

III. A Hybrid Model

In this section, we develop a hybrid model, which reflects further empirical analysis of the Meiji data presented in Ohkawa and associates (1974). We begin the section by addressing the two questions raised at the conclusion of the previous section.

A. Industry Elasticity of Substitution

We rewrite the CES function for industry as :

$$Y_t = \{\alpha_N e^{\lambda_N t} N_t^{\frac{\sigma-1}{\sigma}} + \alpha_k e^{\lambda_K t} K^{\frac{\sigma-1}{\sigma}}\}^{\frac{\rho\sigma}{\sigma-1}} \qquad (8)$$

where the variables are self-explanatory, α_N and α_K are metric-dependent distribution parameters, λ_N and λ_K define the rates of technological progress and ρ indicates the returns to scale (ρ = 1 giving constant returns). With competitive markets and profits maximization, labor's share is given by:

$$S_N = \rho\, \alpha_N\, e^{\lambda_N t}\, N^{\frac{\sigma - 1}{\sigma}}\, Y^{\frac{1 - \sigma}{\sigma\rho}} \qquad (9)$$

or in logarithms:

$$\ln S_N = \ln (\rho\alpha_N) + \lambda_N t + \left(\frac{\sigma - 1}{\sigma}\right) \ln N + \left(\frac{1 - \sigma}{\sigma\rho}\right) \ln Y \qquad (10)$$

Ohkawa has presented the relevant data on the right hand side of equation (10) but, as Kelley and Williamson point out, factor shares for industry are unavailable for the Meiji period. The share of wages in gross value added for manufacturing is reported by Yoshihara (1974, p.9) to be 0.314 over the period 1934-36. However, Ohkawa et al do present a wage index for the manufacturing sector over the Meiji period, and using this as a proxy for industrial wages in general, we compute an estimate of labor income over the period 1885-1920. Clearly, our measure--S_n^*--will be an imperfect measure of the true labor share, S_n. But if we assume that $\ln S_{Nt}^* = \ln S_{Nt} + \varepsilon_t$, where ε_t is a normally distributed serially independent measurement error, consistent estimates of the parameters in equation (10) can be obtained. Clearly, the estimation of equation (10) involves the combined hypotheses of CES technology, profit maximization and competitive markets, but as these are all central ingredients in the Kelley-Williamson model, our approach is appropriate. Also, the existence of measurement error will undoubtedly lead one to expect low explanatory power.

If ρ were different from unity, the coefficients on ln N and the negative of that on ln Y will be statistically different. We test ρ = 1 then by testing this restriction. The estimated difference in the absolute values of these coefficients is not significantly different from zero, implying that we cannot reject the hypothesis of constant returns.

Imposing constant returns, we derived the following estimates[2/] of equation (10):

$$\ln \hat{S}_{Nt} = - 1.456 + 0.003\ t + 0.338\ (\ln N_t - \ln Y_t) \qquad (11)$$
$$(0.134)\ (0.0017)\ (0.205)$$

$R^2 = 0.107$ DW = 1.07 Data Period: 1885-1920
$\hat{\sigma} = 1.5$ $\hat{\alpha}_N = 0.233$ (labor share for the Ogawa-Suits model = 0.197)

The point estimate on $(\ln N_t - \ln Y_t)$ implies an elasticity of substitution greater than unity (1.5) rather than that imposed by Kelley-Williamson. Clearly, the fact that this coefficient is non-significantly different from zero implies that one cannot reject the hypothesis that $\rho = 1$. However, the presence of first-order residual serial correlation biases the estimated standard error, so strictly speaking, statistical inference on this coefficient is not possible. However, our investigations suggest that the assumption used by Kelley and Williamson finds no support in the Meiji data we have constructed.

If anything, our results imply that labor's share will increase as the employment/income ratio rises (ie., an elasticity of substitution greater than unity). Although our data are admittedly 'noisy', the available evidence for the Meiji period points to the Cobb-Douglas specification in industry (as well as in the primary sectors). Indeed, a glance at the computed factor shares in Appendix A offers less formal evidence of the constancy of labor's share. There is no clear sign of its trend declining over time as one would leave expected under the Kelley-Williamson assumption. In the hybrid model, then, we maintain the Cobb-Douglas production technology in both sectors.

B. Propensities to Consume

The industrial labor share estimates and those for agriculture given in Yamada and Hayami (1972) for the Meiji period now facilitate an empirical examination of savings propensities. Applying these shares to nominal GDP and deflating by the consumer price index reported in Ohkawa and associates provides a measure of total real labor income in the Meiji period. The following aggregate consumption function offers striking support for the Kelley-Williamson assumption[3/]:

$$C_t = \underset{(99.4)}{804.93} + \underset{(0.097)}{1.0135}\, YL_t + \underset{(0.052)}{0.4867}\, (Y - YL)_t \qquad (12)$$

$R^2 = 0.988$ DW = 1.177 Data period: 1885-1920

where YL is our measure of real labor income, and Y is aggregate GDP.

It is clear that the estimated propensity to consume out of labor income is not significantly different from one. (Errors in variable considerations would imply that this estimate is downwardly biased, if at all). We also divided labor and non-labor income by source, to test between income obtained in primary and industrial sectors. In both cases (ie., labor and non-labor income), we cannot reject the hypothesis that the propensities to consume are identical in the primary and industrial sectors.

The results do indicate a much greater marginal propensity to save out of non-labor income than that imposed by Kelley and Williamson (0.51 in equation (12), cf. 0.21 in the Kelley-Williamson study). The coefficients on labor and non-labor income are significantly different from each other and they are both significantly positive. Coefficients on non-labor income are significantly less than unity. Overall, these results support the Kelley-Williamson approach to modelling capital accumulation in the Meiji period. We, therefore, adopt equation (12) in the hybrid model, restricting the coefficient on labor income to unity.

C. Other Extensions

The hybrid model also departs from the original Ogawa-Suits formulation in other important respects, and it is to these that we now turn. First, an alternative government expenditure function is adopted. The preferred equation is:

$$\hat{G}_t = -\ 471.17 + 0.013\ TP_t + 2.405\ EDUC_t + 684.84\ DUMW_t \qquad (13)$$
$$\quad (182.21)\ (0.006) \quad (1.402) \quad (68.034)$$
$$+\ 0.3978\ G_{t-1}$$
$$(0.072)$$
$$R^2 = 0.937 \quad DW = 0.23 \quad \text{Data Period: } 1886\text{-}1920$$

where G = government expenditure in constant 1934-36 prices, TP = total population, EDUC = the enrollment rate in compulsory education, and DUMW is a dummy variable = 1 for 1904-05, and 0 otherwise.

In the alternative function, the role of education in government expenditure is explicitly recognized. The equation also takes account of persistence in government expenditure with the inclusion of the lagged dependent variable. The dummy variable is included to account for unusually high levels of expenditure associated with the Russo-Japanese War (1904-05).

Secondly, we treat the share of investment accruing to industry (B) as exogenous rather than as a function of GDP per capita as in the Ogawa-Suits model. This change was required by unacceptably low industry shares in some model simulations.

To complete the system, we require an equation for real labor income, YL. We define real labor income as:

$$YL \equiv \frac{YLN^p + YLN^n}{P_c} \qquad (14)$$

where YLN^i is nominal labor income in sector i, and P_c is the consumer price index. The consumer price index is first expressed in terms of primary and industrial prices in accordance with the following equation estimated over the Meiji period:

$$P_t^c = 0.27\ P_t^p + (1 - 0.27)\ P_t^n \qquad (15)$$
$$(0.0144)$$
$$R^2 = 0.882 \qquad \text{Data period: } 1865\text{-}1920$$

Defining $P_t \equiv P_t^n/P_t^p$ (industry-primary terms of trade), we can write

$$P_t^c = P_t^p\ [0.27 + (1 - 0.27)\ P] \qquad (16)$$

Next we note that, given the marginal conditions:

$$YLN^p = 0.524\ Y_t^p\ P_t^p$$

$$YLN^n = 0.197\ Y_t^n\ P_t^n \qquad (17)$$

Substituting equations (16) and (17) into equation (14) gives:

$$YL_t = (0.197\ Y_t^n\ P_t + 0.524\ Y_t^p)/(0.278 + (1 - 0.278)\ P_t) \qquad (18)$$

The neoclassical version of the model is closed by assuming that investment adjusts passively to ensure savings-investment equality. Thus:

$$I_t = Y_t - C_t - G_t - \overline{X}_t + M_t \qquad (19)$$

in which gross investment cannot be negative (net investment can be the negative of depreciation), so a floor value for I_t is set at zero. If this floor is hit, then the savings-investment equality is satisfied by solving equation (19) for imports. This condition, together with the complete economic system, is described fully in Appendix A.

In the neoclassical model of the Meiji period, the distribution of income is determined by real technological factors (ie., the Cobb-Douglas coefficients) together with the assumptions concerning urban-rural migration (as labor moves into industrial employment, the share of labor income will fall because the individual labor share is appreciably lower than that in the primary sector). The neoclassical model closure is clearly one of several possible closures of the Meiji model. For example, investment could be set exogenously (or modelled independently) and foreign savings adjusted to satisfy the savings-investment condition. To highlight the importance of model closure in analyzing the impact of demographic change on development, we have selected an alternative Kaldorian closure to the system. In this, we assume that investment plan of enterpreneurs are fixed and unaffected by demographic conditions. To ensure adequate savings to guarantee savings-investment equality, the distribution of income is assumed to adjust so that aggregate consumption is just enough to satisfy the equilibrium condition. We achieve this by inverting equation (19)

$$C_t = Y_t - \bar{I}_t - G_t - \bar{X}_t + \bar{M}_t \qquad (20)$$

where the bar signifies an exogenous variable.

To satisfy the aggregate consumption function, this is inverted and solved for YL_t, as follows:

$$YL_t = [1 / (1 - 0.487)] \cdot [C_t - 910 - 0.487\, Y_t] \qquad (21)$$

Thus, savings adjusts to equality with investment by a shift in income distribution[4/]. Clearly, the two models will be observationally identical if the solution value for investment in the neoclassical version exactly equals the exogenous investment level assumed in the Kaldorian version. Given that, the neoclassical model will imperfectly track actual investment one would expect the Kaldoran model to out-perform it in traceability tests. What is important, however, is the fact that the two models will behave very differently under alternative demographic simulations. We explore these results in the following section.

IV. Numerical Experiments

The key results are reported in Table 1. In the reference run, we follow the Ogawa-Suits study in assuming that both birth and death rates are given from actually observed data for the period 1885-1920 in Japan. In the first demographic counterfactual simulation (no.1), we impose the fertility characteristics of developing countries in Asia today (see the Ogawa-Suits study for a complete description of the demographic model).

Comparisons of GDP per capita under the neoclassical closure (first column in Table 1) in the reference run and in the demographic simulation provide a very similar result to that reported in Ogawa-Suits work; indeed, the reduction in per capita GDP is even more pronounced in the hybrid model. Its value in 1920 is less than 60 % of the initial value, despite some moderate growth up to the early

Table 1. Reference Run

Type of closure	Neoclassical				Kaldorian		
Year	Y/TP	YL	YL/Y	X-M	Y/TP	YL	YL/Y
1885	.100	1413	.36	-57	.100	1025	.26
1890	.106	1653	.39	-158	.115	1637	.35
1895	.109	1674	.37	-225	.131	2194	.40
1900	.129	1905	.34	-266	.148	2803	.43
1905	.134	2011	.32	-799	.145	1695	.25
1910	.135	2163	.33	-276	.154	2640	.35
1915	.162	2477	.29	-117	.173	3679	.40
1920	.197	3253	.30	-636	.209	4580	.39

Table 2. Demographic Simulation 1

Type of closure	Neoclassical				Kaldorian		
Year	Y/TP	YL	YL/Y	X-M	Y/TP	YL	YL/Y
1886	.099	1386	.36	-52	.099	1062	.27
1890	.103	1637	.39	-158	.112	1559	.34
1895	.102	1629	.37	-225	.128	2164	.39
1900	.113	1808	.35	-266	.147	2974	.45
1905	.114	1862	.35	-799	.144	2316	.34
1910	.092	1773	.37	-276	.152	2707	.35
1915	.073	1541	.37	-482	.172	3824	.41
1920	.059	1732	.47	-956	.205	4700	.40

years of the 20th century.

The share of labor income oscillates somewhat over the simulation period in both reference run and demographic simulation, due in part to labor movement to industrial employment and exogenous changes in the terms of trade. In the demographic simulation, the floor investment limit was hit in the period 1912-1920, and it is clear from Table 1 that the balance of payments deteriorates towards the end of the simulation period in order to satisfy non-investment final demands.

Nevertheless, the results obtained under the Kaldorian closure provide an interesting contrast. Changes in the model performance under the demographic simulation are marginal, with per capita GDP only slightly below the reference level, and the share of labor actually higher under faster labor growth after an initial dip below its reference level. It is thus not at all clear what would have happened to Meiji Japan under typical Asian fertility. The answer to this question depends on one's view of the development process. If the Kaldorian view is appropriate for Meiji Japan, then, Japanese economic historians have been correct in ignoring the role of low population growth in explaining the Meiji 'miracle'.

This result is reinforced by considering the effects of imposing Asian mortality on Meiji Japan (in addition to fertility), again as fully described in Ogawa-Suits modelling work. This alternative demographic assumption (demographic simulation 2) involves a drastic and substantial change in the population and labor force in Japan, so much that under the neoclassical closure the failure to maintain investment at replacement level resulted in rapid depletion of capital stock and a complete collapse of the model simulation. However, such a catastrophe is not a feature of the Kaldorian model, as may be gathered from inspection of Table 3. Per capita GDP is naturally lower than in the reference run by the close of the period, but it is only 74% of the reference figure in 1920. Moreover, excluding the exceptional years around the Russo-Japanese War, output per capita is simulated to grow even if Meiji Japan were experiencing the fertility and mortality characteristics of present-day Asian developing countries. Labor's share of GDP is expectedly lower, especially at the start of the simulation, but by the end it is close to its reference value.

Table 3. Demographic Simulation 2

Kaldorian Closure				
	Y/TP	YL	YL/Y	YL/N
1886	0.097	926	0.24	0.043
1890	0.106	1469	0.32	0.064
1895	0.114	1988	0.36	0.081
1900	0.128	2848	0.41	0.100
1905	0.120	2159	0.30	0.068
1910	0.123	2556	0.31	0.072
1915	0.136	3959	0.38	0.099
1920	0.154	5032	0.37	0.112

Notes

1/ As will be clear in what follows, stability conditions require that $g''(k)$ be negative, so that $g(k^*)$ defines the maximum.

2/ Estimated standard errors of the coefficients are given in parentheses.

3/ Adding the lagged dependent variable did not significantly improve the fit, and the coefficient on C_{t-1} was not significantly different from zero.

4/ The amendments involved in the Kaldorian closure are set out in Appendix B.

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Appendix A

Hybrid Meiji Model: Neoclassical Closure

EQ.#	Economic Model	Description
N1	$Y^p_t = [\,0.157 - 0.000126\,t - 0.00011\,t^2 + 0.0000048\,t^3 - 0.000005\,(t-12)^3 \cdot D1 + 0.000001\,(t-24)^3 \cdot D2\,] \cdot [\,e^{0.0114} \cdot K^p_{t-1}\,]^{0.196} \cdot [\,e^{0.0194} \cdot N^p_t\,]^{0.524} \cdot LD_t^{0.280}$	Primary production
N2	$Y^n_t = [\,0.9985\,] \cdot [\,e^{t\,(0.485 + 0.185\,T1 - 0.120\,t + 0.0134\,t^2 - 0.00054\,t^3 + 0.00054\,(t-8)^3 \cdot D3 + 0.000001\,(t-17)^3 \cdot D4)} \cdot K^n_{t-1}\,]^{0.803} \cdot [\,e^{t\,(0.823 + 0.315\,T1 - 0.205\,t + 0.023\,t^2 - 0.001\,t^3 + 0.0009\,(t-8)^3 \cdot D3 + 0.0000016\,(t-17)^3 \cdot D4)} \cdot N^n_t\,]^{0.197}$	Industrial production
N3	$D^p_t = 21.457 + \underset{(0.001)}{0.0137}\,K^p_{t-1}$	Primary sector depreciation
N4	$D^n_t = 50.343 + \underset{(0.001)}{0.0694}\,K^n_{t-1}$	Industry sector depreciation
N5	$V_t = 0.575 - \underset{(0.0002)}{0.0000163}\,CW_t - \underset{(0.0003)}{0.00015}\,EDUC_t + [\,- \underset{(2.27)}{0.0637}\,(Y_{t-1}/TP_{t-1}) + \underset{(27.8)}{42.32}\,(Y_{t-1}/TP_{t-1})^2 - \underset{(107.2)}{210.66}\,(Y_{t-1}/TP_{t-1})^3 - \underset{(1859.3)}{846.19}\,(Y_{t-1}/TP_{t-1} - 0.14)^3 \cdot D5\,] \cdot D6 - \underset{(0.04)}{0.094}\,(1 - D2) \cdot \ln\,(Y_{t-1}/TP_{t-1}) + \underset{(0.01)}{0.0194}\,T2 - \underset{(0.008)}{0.0293}\,T3$	Labor force participation
N6	$A_t = -\,0.0176 + \underset{(0.003)}{1.016}\,A_{t-1} - \underset{(0.003)}{0.00012}\,[\,(Y^n_{t-1}/Y^n_{t-2}) - 1\,]$	Primary employment share
N7	$Y_t = Y^p_t + Y^n_t$	Definition of GDP
N8	$G_t = -\,471.17 + 0.014\,TP_t + 2.405\,EDUC_t + 0.398\,G_{t-1} + 684.84\,DUMW$	Government expenditure
N9	$YL_t = (0.197\,Y^n_t\,P_t + 0.524\,Y^p_t)/(0.278 + (1 - 0.278)\,P_t)$	Real labor income
N10	$C_t = 910 + YL_t + 0.487\,(Y_t - YL_t)$	Consumption

N11	$I_t = Y_t - C_t - G_t - \bar{X}_t + M_t$	Neoclassical closure
	$: \text{ if } Y_t - C_t - G_t - \bar{X}_t + \bar{M}_t \geq 0$	
	$I_t = 0$	Investment floor
	: otherwise	
N12	$M_t = \bar{M}_t \quad : \text{ if } Y_t - C_t - G_t - \bar{X}_t + \bar{M}_t \geq 0$	Import
	$M_t = C_t + G_t + X_t - Y_t \quad : \text{ otherwise}$	
N13	$I^p_t = (1 - B_t)\, I_t$	Primary sector investment
N14	$I_t = B_t\, I_t$	Industrial investment
N15	$K^p_t = K^p_{t-1} + I^p_t - D^p_t$	Primary sector capital stock
N16	$K^n_t = K^n_{t-1} + I^n_t - D^n_t$	Industry sector capital stock
N17	$N_t = V_t \cdot WP_t$	Total employment
N18	$N^p_t = A_t \cdot N_t$	Primary sector employment
N19	$N_t = (1 - A_t) \cdot N_t$	Industrial employment

Endogenous variables:

- Y = gross domestic product (million yen at 1934-36 constant prices)
- C = personal consumption (million yen at 1934-36 constant prices)
- G = government spending (million yen at 1934-36 constant prices)
- M = imports (million yen at 1934-36 constant prices)
- K = end-of-year capital stock (million yen at 1934-36 constant prices)
- D = depreciation (million yen at 1934-36 constant prices)
- N = labor force (1,000 persons)
- V = labor force participation rate
- A = proportion of the labor force in the primary sector
- I = gross investment (million yen at 1934-36 constant prices)
- YL = real labor income (millions of 1934-36 yen)

Exogenous variables:

- LD = agricultural land stock (1,000 ha)
- TP = total population (1,000 persons)
- CW = child-woman ratio
- WP = working-age (10-64) population (1,000 persons)
- EDUC = enrollment rate in compulsory education
- B = proportion of gross savings in the non-primary sector
- X = exports (million yen at 1934-36 constant prices)
- P = consumer price index (1936-36-1.0)
- T1 = deletor variable (= 1 for 1895)
- T2 = deletor variable (= 1 for 1905)
- T3 = deletor variable (= 1 for 1915)
- D1 = dummy variable (= 1 if t is greater than 12, and is otherwise 0)
- D2 = dummy variable (= 1 if t is greater than 24, and is otherwise 0)
- D3 = dummy variable (= 1 if t is greater than 8, and is otherwise 0)
- D4 = dummy variable (= 1 if t is greater than 17, and is otherwise 0)
- D5 = dummy variable (= 1 if $0 < Y_{t-1}/TP_{t-1} \leq 0.140$)
- D6 = dummy variable (= 1 if $0 < Y_{t-1}/TP_{t-1} \leq 0.163$)

- DUMW = dummy variable (= 1 for 1904 and 1905)
- t = time
- n = non-primary sector
- p = primary sector

Appendix B

Alternative Equations for Kaldorian Closure

N9 becomes K9: $YL_t = (1 / (1 - 0.487)) \; (C_t - 910 - 0.487 \, Y_t)$

N10 becomes K10: $C_t = Y_t - I_t - G_t - \overline{X}_t + M_t$

N11 becomes K11: $I_t = \overline{I}_t$

N12 becomes K12: $M_t = \overline{M}_t$