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### SOME STRUCTURAL CHANGES IN THE UNITED STATES AND JAPANESE ECONOMIES

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Some Structural Changes in the United States  
and Japanese Economies

Mitoshi Yamaguchi and Hans P. Binswanger

I. Introduction

The relationships among capital accumulation, population growth and technical change in economic development are still poorly understood. General equilibrium theory does provide us with some answers: Population growth will tend to increase agricultural demand and output and turn terms of trade in favor of agriculture, because agricultural demand is inelastic. Or technical change in agriculture will tend to increase agricultural demand to some extent due to an income and price effect working in favor of agricultural demand. Nonagricultural demand will increase as well due to the income effect of the technical change, but there will be a terms of trade effect working in the opposite direction. General equilibrium theory alone cannot predict which effect will dominate and hence we do not know whether nonagricultural output can be expected to increase after a technical change in agriculture. And especially, questions of relative magnitude of effects require numerical analysis.

The approach generally chosen to overcome the weaknesses of theory alone is simulation. A model is constructed and parameter values and initial conditions are chosen for it. Then the model is simulated over shorter or longer periods.

This immediately raises the question whether it is reasonable to assume a model's parameter values as constant over long periods. If the model is simple, such as a two sector general equilibrium model, it usually only models some subset of economic processes. Technical change or capital accumulation may be treated exogenously, despite evidence that they are at least partially endogenous. These left out parts are likely to affect the parameters of the relationships actually modeled. In simple models there is, therefore, little assurance of constancy of parameters over longer periods. And, indeed, we generally find that the models do quite well for short periods but fail to trace historical paths of economies for prolonged periods.

One way out of this dilemma is to make the models more inclusive and complicated. But as more complex economic relationships are introduced in a model, such as endogenous technical change, parameter values have to be found for functional relationships about which much less empirical knowledge is available than about the demand for food or production functions. Also, the models become complex and it is difficult to trace causal chains within the model as some exogenous variable is altered. The model will trace the consequences but it becomes harder to understand its internal dynamics.

This paper is an attempt to quantify some interaction effects among capital accumulation, population growth and sectoral technical change in economic development. We tried to find a balance in the difficult trade-off just mentioned. We built a simple dynamic general equilibrium model

along neoclassical lines. It is an agricultural-nonagricultural two sector model of a closed economy. Due to its simplicity, causal chains are easily traced. But we do not pretend to capture a complete model of development and recognize that the parameters of the model may change over time, i.e., that there is structural change. Therefore no simulations are performed with the model. Instead, we tried to find parameter values for the model at various stages of the development of the Japanese and U. S. economies, and observe the model under widely different resource endowments between the economies and over time. Parameter values come from GNP statistics and econometric studies of other authors. At each time the model measures what we call growth rate multipliers, i.e., the effects of changes in growth rates of exogenous variables on growth rates of endogenous variables. Changes in these growth rate multipliers over time and between the countries trace structural differences between the economies and within the economies over time.

The model treats the following variables as exogenous:

- Technical change in agriculture
- Technical change in nonagriculture
- Capital accumulation rate
- Growth rate of labor
- Growth rate of population.

These variables we treated as exogenous because there is wide disagreement about how to model them endogenously and because they may be policy targets and policy makers need to know what effects changes in

them have on the economy. There are eight endogenous variables:

Per capita income

Sectoral outputs (2)

Sectoral allocation of labor and capital (4)

Terms of trade.

The model and the general approach does not differ too much from Kelley and Williamson's work (1972, 1973) in this area. However, apart from our decision not to simulate, the differences of the model are significant and strongly affect the questions one can ask with the model and the conclusions emerging from the analysis.

Most importantly, we treat technical change in agriculture independently from technical change in nonagriculture on the grounds that technical change is sector specific. Kelley and Williamson used a factor augmenting framework to be able to trace the effects of biased technical change. They assumed that augmentation parameters are identical in the production functions of the two sectors. Rates of technical change in the two sectors, therefore, cannot vary independently although they differ slightly due to differences in production function parameters. However, the institutional organization of research and development in the two sectors is quite different and it is hard to find an example of a technical change which benefits both sectors equally.

Another departure is the treatment of population independently from labor. It is not assumed that an increase in population automatically results in an equiproportional increase in labor, but the possibility is

admitted that strong population growth may depress the labor participation rate. Unless this is allowed, harmful effects from population growth can only come from diminishing returns to labor. If these set in slowly an optimistic picture of the effect of population growth on the economy emerges.

A third difference is that our model introduces factor market imperfections, primarily in the form of an agricultural-nonagricultural wage differential, with wages in agriculture being lower than in nonagriculture. Unless this is admitted there is no way to explain the much higher proportion of agricultural labor in total labor than of agricultural output in total income (Table 3). This assumption has two effects which will be reflected in the conclusions: There is an apparent bonus to be had from transferring factors from agriculture to the more productive nonagricultural sector. To the extent that the wage differential occurs because costs of maintaining a worker in nonagriculture are higher than in agriculture, the higher productivity in nonagriculture is needed to pay for this cost and the bonus to be had does not come free as in the labor surplus models of Fei and Ranis (1964). The other consequence, as Johnson (1966) has shown, is that the market imperfection flattens the agricultural-nonagricultural transformation curve.

Kelley and Williamson's model has a more sophisticated model for the demand side. In our model simple log linear demand functions are assumed. We also do not model capital accumulation endogenously.

The model is similar to Tolley and Smidt's (1964) model of the effects of technical change in U. S. agriculture. The departures from this model are that population growth and nonagricultural technical change are treated explicitly here.



## II. The Model

### Static Relationships

The Total Demand for agricultural products is as follows, with the notations summarized in Appendix A.<sup>1</sup>

$$Y_1 = f(a, Q, P, E, ) = aQP^\eta E^\epsilon. \quad (1)$$

In this study, the demand for agricultural products ( $Y_1$ ) is assumed to be a function of real per capita income ( $E$ ), the price of agricultural products relative to nonagricultural products ( $P$ ), population ( $Q$ ), and a demand shifter ( $a$ ).<sup>2</sup> A log-log linear demand function is assumed.

The Agricultural Production Function can be expressed as follows:

$$Y_1 = g(L_1, K_1, T_1) = T_1 L_1^\alpha K_1^\beta. \quad (2)$$

where  $L_1$  = agricultural labor;  $K_1$  = agricultural capital;  $T_1$  = technical change in agriculture.

Nonagricultural Products are produced by using nonagricultural capital ( $K_2$ ) and nonagricultural labor ( $L_2$ ):

$$Y_2 = h(L_2, K_2, T_2) = T_2 L_2^\gamma K_2^\delta \quad (3)$$

where  $T_2$  = technical change in nonagriculture.

The adding up constraint for labor is

$$L = L_1 + L_2 = Q - N \quad (4)$$

where  $Q$  = population and  $N$  = nonlabor.

The adding up constraint for capital is

$$K = K_1 + K_2. \quad (5)$$

The demand for factors in each sector depends on the price of the output, the rate of return paid for the factor, and the marginal productivities of the factors. To allow for market imperfections the wage rate is equal to a fraction of the value of the marginal product.

The Labor Demands in Each Sector are:

$$w_1 = P_1 m_{L_1} g'_{L_1} \quad (6)$$

$$w_2 = P_2 m_{L_2} h'_{L_2}. \quad (7)$$

The Capital Demands in Each Sector are:

$$r_1 = P_1 m_{K_1} g'_{K_1} \quad (8)$$

$$r_2 = P_2 m_{K_2} h'_{K_2}. \quad (9)$$

In the Intersector Mobility Condition for Wage Rate labor is assumed to migrate to the nonagricultural sector only if the wage rate there exceeds the agricultural wage rate by a given proportion ( $m_w$ ). This leads to the equilibrium condition

$$w_1 = m_w w_2 \quad (10)$$

The Intersector Mobility Condition for Interest Rate is:

$$r_1 = m_r r_2. \quad (11)$$

Similarly, capital flows from agriculture to nonagriculture if  $r_1 < m_r r_2$ .

Finally, Total Nominal Income (P'QE) is the sum of the agricultural nominal income ( $P_1 Y_1$ ) plus the nonagricultural nominal income ( $P_2 Y_2$ )

$$P'QE = P_1 Y_1 + P_2 Y_2. \quad (12)$$

where P' is the general price level.

Equation (12) is needed because real per capita income (E) must be an endogenous variable. It is determined by  $Y_1$ ,  $Y_2$ ,  $P_1$ , and  $P_2$ , which are all endogenous in the model, and enters the demand relationship. If this aspect were to be neglected, as in the Tolley-Smidt model (1964), simulation would lead to erroneous results.

The six equations from equation (6) to (11) can be reduced to two equations as follows:

$$P \frac{g'_{L_1}}{h'_{L_2}} = N_w \quad (13)$$

and

$$P \frac{g'_{K_1}}{h'_{K_2}} = N_r \quad (14)$$

where  $N_w = m_w m_{L_2} / m_{L_1}$  is the degree of imperfection of the labor markets (15)

$N_r = m_r m_{K_2} / m_{K_1}$  is the degree of imperfection of the capital market (16)

$$P = P_1 / P_2. \quad (17)$$

Dynamic Relationships

$\dot{X}$  is defined as a proportional change of variable X over time,  
 $\frac{\partial X}{\partial t} \cdot \frac{1}{X}$ . Differentiating equation (1) totally and converting in  
proportional rates of changes, the dynamic equivalent of the demand  
relation is:

$$\dot{Y}_1 = \dot{a} + \dot{Q} + \eta \dot{P} + \epsilon \dot{E} \quad (18)$$

where  $\eta$  is the price elasticity of demand for agricultural products, and  
 $\epsilon$  is the income elasticity.

If  $\dot{T}_1$  is defined as the percentage rate of change of output per unit  
of input in the agricultural sector,  $\alpha$  as the share of product accruing  
to labor in agriculture, and  $\beta$  as the share of product accruing to the  
capital inputs, then the dynamic relations corresponding to the production  
functions (2) and (3) become:

$$\dot{Y}_1 = \dot{T}_1 + \alpha \dot{L}_1 + \beta \dot{K}_1 \quad (19)$$

If  $\gamma$  is defined as the share of product accruing to labor in the  
nonagricultural sector and  $\delta$  as the share of product accruing to the  
capital input:

$$\dot{Y}_2 = \dot{T}_2 + \gamma \dot{L}_2 + \delta \dot{K}_2 \quad (20)$$

The adding up constraints (4) and (5) lead to the following relations:

$$L_1 \dot{L}_1 + L_2 \dot{L}_2 = \dot{L}L \quad (21)$$

$$K_1 \dot{K}_1 + K_2 \dot{K}_2 = \dot{K}K. \quad (22)$$

The factor mobility condition (13) and (14) can be converted into the following equation (see Appendix B for proof):

$$\dot{K}_1 - \dot{K}_2 - (\dot{L}_1 - \dot{L}_2) = \dot{N}_w - \dot{N}_r \quad (23)$$

which comes from the condition

$$\frac{g'_{L_1}/h'_{L_2}}{g'_{K_1}/h'_{K_2}} = \frac{N_w}{N_r}. \quad (24)$$

Equations (13) and (14) also lead to the following relationship (see Appendix B for proof):

$$\dot{P} = \dot{T}_2 - \dot{T}_1 + (\gamma - \alpha) (\dot{L}_1 - \dot{K}_1) + \delta \dot{N}_r + \gamma \dot{N}_w. \quad (25)$$

Equation (25) relates the terms of trade, technical change, sectoral allocation of resources, etc. Assuming, for simplicity, that the degree of imperfection remains constant (i.e.,  $\dot{N}_r$  and  $\dot{N}_w$  equal zero), then this equation shows that the rate of change of the terms of trade depends on (1) the difference in the rate of technical change in the two sectors, (2) the difference in the labor shares in the two sectors, and (3) the change in the labor-capital ratio in the agricultural sector.

Finally, equation  $P_1 Y_1 + P_2 Y_2 = P'QE$  would be changed as follows:

$$\lambda \dot{Y}_1 + (1-\lambda) \dot{Y}_2 - \dot{E} = \dot{Q}. \quad (26)$$

This holds prices constant for the income comparison where,

$$\lambda = \frac{P_1 Y_1}{P'QE} = \frac{\text{agricultural income}}{\text{total income}}$$

Table 1 and Table 2 give a summary of the dynamic relationships.

The equations are exhibited in matrix form with the endogenous variables on the left hand side and the exogenous variables on the right hand side.

In other words, our model is expressed in matrix form as follows:

$Ax = b$  ( $A = 8 \times 8$ ,  $x = 8 \times 1$ , and  $b = 8 \times 1$ ) or  $x = A^{-1}b$  where,  $x$  is a vector of endogenous variables,  $b$  is a vector of exogenous variables, and the elements of the  $A^{-1}$  matrix are growth rate multipliers. Therefore, a growth rate multiplier shows how an exogenous variable effects an endogenous variable<sup>3</sup>. As an example, the  $(A^{-1})_{2,4}$  element is  $\partial Y_2 / \partial L$ , which indicates by how much the rate of change of nonagricultural output increases due to an increase in labor growth (The multipliers of those exogenous variables which appear twice in the vector  $b$ , such as technical change in both sectors, are the sum of the two corresponding elements of  $A^{-1}$ ).

Table 1. A matrix exposition of the two sector model

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\epsilon \\ 1 & 0 & 0 & -\beta & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & -\delta & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{L_1}{L} & \frac{L_2}{L} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{K_1}{K} & 0 & 0 & 0 & \frac{K_2}{K} & 0 & 0 \\ 0 & 0 & 0 & 1 & -1 & -1 & 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & \gamma - \alpha & 0 & \alpha - \gamma & 0 & 0 & 1 & 0 \\ \lambda & 1 - \lambda & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 \end{pmatrix}
 \begin{pmatrix} \dot{a} + \dot{Q} \\ \dot{T}_1 \\ \dot{T}_2 \\ \dot{L} \\ \dot{K} \\ \dot{N}_w - \dot{N}_r \\ \dot{T}_2 - \dot{T}_1 + \delta \dot{N}_r + \alpha \dot{N}_w \\ \dot{Q} \end{pmatrix}
 =
 \begin{pmatrix} \dot{Y}_1 \\ \dot{Y}_2 \\ \dot{K}_1 \\ \dot{K}_2 \\ \dot{L}_1 \\ \dot{L}_2 \\ \dot{P} \\ \dot{E} \end{pmatrix}$$

Table 2. Parameter values of matrix A.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Year	Labor's share in agric. output	Capital's share in agric. output	Labor's share in nonagric. output	Capital's share in nonagric. output	Price elast. of agric. goods	Income elast. of agric. goods	Prop. of labor in agric.	Prop. of capital in agric.	Share of income produced by agric.
	$\alpha = \frac{w_1 L_1}{Y_1}$	$\beta = \frac{r_1 K_1}{Y_1}$	$\gamma = \frac{w_2 L_2}{Y_2}$	$\delta = \frac{r_2 K_2}{Y_2}$	$\eta$	$\epsilon$	$\frac{L_1}{L}$	$\frac{K_1}{K}$	$\lambda = \frac{P_1 Y_1}{PQE}$
					JAPAN				
1880	0.58	0.42	0.70	0.30	-0.60	0.40	0.75	0.88	0.47
1890	0.54	0.46	0.70	0.30	-0.60	0.40	0.63	0.85	0.32
1900	0.56	0.44	0.70	0.30	-0.60	0.40	0.57	0.79	0.32
1910	0.56	0.44	0.70	0.30	-0.60	0.40	0.54	0.71	0.34
1920	0.55	0.45	0.70	0.30	-0.60	0.45	0.51	0.58	0.26
1930	0.61	0.39	0.70	0.30	-0.60	0.35	0.47	0.49	0.19
1940	0.55	0.45	0.65	0.35	-0.60	0.35	0.42	0.38	0.16
1950	0.55	0.45	0.85	0.15	-0.60	0.45	0.45	0.32	0.22
1960	0.57	0.43	0.75	0.25	-0.60	0.45	0.30	0.24	0.13
					U.S.A.				
1880	0.70	0.30	0.67	0.33	-0.60	0.58	0.46	0.57	0.28
1890	0.80	0.20	0.67	0.33	-0.55	0.50	0.42	0.54	0.24
1900	0.70	0.30	0.67	0.33	-0.45	0.45	0.38	0.44	0.19
1910	0.55	0.45	0.67	0.33	-0.35	0.34	0.30	0.38	0.15
1920	0.60	0.40	0.65	0.35	-0.25	0.20	0.26	0.33	0.12
1930	0.45	0.55	0.65	0.35	-0.25	0.20	0.23	0.27	0.12
1940	0.60	0.40	0.65	0.35	-0.25	0.20	0.19	0.28	0.08
1950	0.50	0.50	0.66	0.34	-0.35	0.26	0.14	0.26	0.06
1960	0.40	0.60	0.69	0.31	-0.25	0.25	0.10	0.24	0.06

Sources: See Appendix C.



Table 3. Signs of growth rate multipliers of exogenous or endogenous variables

Exogenous variables	Sign of effect on growth rate of endogenous variables							
	Real agri-cultural output ( $\dot{Y}_1$ )	Real nonagri-cultural output ( $\dot{Y}_2$ )	Agri-cultural capital ( $\dot{K}_1$ )	Nonagri-cultural capital ( $\dot{K}_2$ )	Agri-cultural labor ( $\dot{L}_1$ )	Nonagri-cultural labor ( $\dot{L}_2$ )	Terms of trade ( $\dot{P}$ )	Real per capita income ( $\dot{E}$ )
Growth rate of population ( $\dot{Q}$ )	+	-	+	-	+	-	- <sup>1</sup>	-
Rate of technical change in agriculture ( $\dot{T}_1$ )	+	+	-	+	-	+	-	+
Rate of technical change in nonagriculture ( $\dot{T}_2$ )	-	+	-	+	-	+	+	+
Growth rate of total labor ( $\dot{L}$ )	+	+	-	+	+	+	+	+
Growth rate of total capital ( $\dot{K}$ )	+	+	+	+	-	+	-	+

<sup>1</sup> With some exceptions, when values, however, are close to zero (see Table 7).

### III. Empirical Results

Table 2 shows the parameter values which were used in the empirical analysis. The sources of these parameters are discussed in Appendix C in detail. A striking feature of the data is that agriculture in both countries is capital-intensive relative to nonagriculture for most of the time. (The exception is the U. S. from 1880 to 1900). The capital coefficient in agriculture is almost always larger than the one in non-agriculture. This is so because land is included as capital in the computation of the capital coefficient.

Throughout the period agriculture was a more important sector in Japan than in the U. S. But in both countries the relative decline of agriculture as a sector of the economy is dramatic. Income derived from agriculture declined from 47% of national income to 13% in Japan, while the decline in the U. S. was from 28% to 6%. This decline is what causes most of the changes in the behavior of the model over time.

In both countries, however, the proportion of labor in agriculture exceeds the share of income produced in agriculture. Given that agriculture is the capital intensive sector, this can only be explained by labor market imperfections. Indeed, it is in the proportions  $L_1/L$  and  $K_1/K$  that market imperfections are reflected in the A matrix since both  $N_w$  and  $N_r$  do not occur in that matrix. The production parameters and the fractions  $L_1/L$  and  $K_1/K$  are two different measures of factor intensities in the two sectors. They agree most of the time, except from 1940 to 1960 in Japan and from 1880 to 1900 in the U. S. This inconsistency is due to the factor market distortions.

Since agriculture is generally the capital intensive sector as measured by production parameters,  $K_1/K$  should be larger than  $\lambda$ , which is always the case. But  $K_1/K$  exceeds  $\lambda$  by so much in both periods that it is reasonable to assume that there existed capital market imperfections as well as labor market imperfections. But data on returns to capital in both sectors are hard to come by to substantiate this suspicion.

At the beginning of the period, income and price elasticities for agricultural goods are relatively high in both countries. According to available empirical studies by other economists (see Appendix), these elasticities declined rapidly in the U. S., but stayed almost constant in Japan. It may be that incomes will have to grow still further before a decline in food demand elasticities sets in in Japan.

Table 3 shows the signs of the effects of the rates of change of the exogenous variables on the endogenous ones. The signs generally do not change between the countries or over time.<sup>4</sup> The exceptions occur in terms of trade effects during those periods when the two measures of capital intensities do not agree. But values of the multipliers which do change signs are so small that this is of little relevance. Structural differences are hence not reflected in sign changes but in changes of magnitudes. Where qualitative general equilibrium theory can make sign predictions for these effects (such as the effects of technical changes on incomes and outputs, etc.), the signs, of course, agree with the theoretical derivations (see Jones, 1965, for a comparison with qualitative general equilibrium results). In many cases qualitative

analysis, however, cannot establish signs unambiguously. That is also where the more interesting results of quantitative analysis arise.

Consider in particular technical change in the two sectors: Technical change in each sector increases real per capita income and turns terms of trade against the sector experiencing the technical change. Income and price effects work in the same direction and the output of the sector experiencing the technical change and price decline is increased. This is what qualitative general equilibrium theory predicts.

What qualitative analysis cannot predict, however, is that technical change in nonagriculture tends to decrease agricultural output. The demand and income elasticities of agricultural goods are much less than one (in absolute magnitude) and larger than one for nonagricultural goods. The income effect to increase agricultural demand is not sufficient to offset the negative effect on agricultural demand of higher agricultural prices. Also, much of the income increase goes into non-agricultural demand due to the high income elasticity for those goods.

Technical change in agriculture tends to increase nonagricultural output. This is asymmetric to the effect of technical change in non-agriculture on agricultural output. The reason is again the difference in price and income elasticities of demand in the two sectors.

Due to this asymmetry, technical change in agriculture pushes resources out of the sector. Agricultural labor and capital decrease. The small increase in agricultural demand resulting from the income increase cannot offset the reduced input requirements for producing the

agricultural output after the technical change. Contrariwise, technical change in nonagriculture draws resources into that sector.

Table 4 shows the magnitude of these effects and their changes.<sup>5</sup> The effect of agricultural technical change on per capita income (column 1, Table 4) is, of course, larger the larger the agricultural sector. Hence, it is larger in Japan than in the U. S. throughout the period and it declines very strongly over time in both countries. It is always smaller than the effect of nonagricultural technical change on per capita income input (column 4, Table 4) because in both countries the nonagricultural sector is larger than the agricultural one for the whole period (column 9, Table 2). But sector size alone cannot explain the difference. In 1880 in Japan almost 50% of income was produced in agriculture, but the agricultural technical change multiplier is substantially smaller than the nonagricultural one. The difference occurs because of the market imperfections, and the larger transfer of resources to the higher productivity nonagricultural sector arising from nonagricultural technical change than from agricultural technical change.

On the other hand, sector size largely determines the extent to which the nonagricultural sector can expand at the expense of the agricultural one. Therefore, nonagricultural technical change increases nonagricultural output and decreases agricultural output (columns 6 and 5, Table 4) much more in Japan than in the U. S. and much more at the beginning of the period than at the end.

Table 4. Growth Rate Multipliers (GRM) of Technical Changes and Capital in Japan and the U. S.

10-Year Span Beginning	(1) $ET_1$	(2) $Y_1^T$	(3) $Y_2^T$	(4) $L_1^T$	(5) $ET_2$	(6) $Y_1^T$	(7) $Y_2^T$	(8) $L_2^T$	(9) $PT_2$	(10) $EK$	(11) $Y_1^K$	(12) $Y_2^K$	(13) $PK$
	<u>JAPAN</u>												
1880	.68	.88	.50	-.16	.91	-.23	1.91	.87	.98	.56	.30	.78	-.13
1890	.56	.84	.43	-.23	.97	-.20	1.51	.46	.97	.55	.32	.65	-.18
1900	.50	.81	.36	-.24	.90	-.23	1.43	.39	.98	.49	.29	.59	-.15
1910	.48	.80	.31	-.24	.83	-.26	1.39	.36	.98	.46	.27	.55	-.15
1920	.39	.78	.26	-.24	.86	-.21	1.24	.23	1.00	.44	.29	.49	-.15
1930	.34	.72	.25	-.28	.96	-.27	1.24	.24	1.00	.42	.20	.47	-.09
1940	.28	.70	.20	-.29	.95	-.27	1.18	.19	1.00	.46	.22	.51	-.10
1950	.31	.73	.19	-.24	.85	-.22	1.16	.17	1.01	.27	.29	.26	-.29
1960	.20	.69	.12	-.30	.91	-.19	1.08	.08	1.00	.31	.25	.32	-.18
	<u>U. S.</u>												
1880	.36	.81	.19	-.20	.78	-.15	1.14	.13	1.00	.37	.19	.43	.03
1890	.35	.72	.23	-.29	.82	-.14	1.12	.11	1.00	.34	.10	.42	.13
1900	.33	.60	.27	-.41	.84	-.07	1.05	.05	1.00	.37	.15	.43	.03
1910	.30	.45	.27	-.58	.86	-.06	1.03	.03	1.00	.42	.19	.46	-.12
1920	.28	.31	.28	-.72	.90	-.07	1.03	.03	1.00	.43	.10	.47	-.05
1930	.24	.30	.23	-.72	.89	-.07	1.02	.02	1.00	.44	.14	.48	-.20
1940	.21	.29	.20	-.74	.93	-.06	1.02	.02	1.00	.41	.09	.44	-.05
1950	.15	.39	.14	-.65	.96	-.10	1.02	.02	1.00	.40	.16	.42	-.17
1960	.13	.29	.12	-.78	.94	-.01	1.00	.00	1.00	.37	.17	.39	-.31

$ET_j$ : GRM of technical change in sector j on per capita income.

$Y_{1j}^T$ : GRM of technical change in sector j on output in sector i.

$PT_2$ : GRM of technical change in the nonagricultural sector on the terms of trade.

$EK, Y_1^K, Y_2^K, PK$ : GRM of capital on per capita income, agricultural output, nonagricultural output, and the terms of trade, respectively.

On the other hand, the strength with which technical change in agriculture pushes labor out of that sector does not decline, but increases in both countries (column 4, Table 4).

The effects of capital on growth (column 10, Table 4) are less in magnitude than the effects of technical change in nonagriculture. This again re-emphasizes the crucial role of technical change for growth. According to the income elasticities, the increase in per capita income arising from the increased capital stock is spent primarily on nonagricultural goods (columns 10 and 11, Table 4).

Terms of trade hardly change in response to a growth in the capital stock (column 13, Table 4). This is so because in a model like ours, the transformation curve has very little curvature. Johnson (1966) indeed shows that, unless differences in capital intensities between the two sectors are extremely large, a two-sector model with two Cobb-Douglas production functions has a transformation function which is almost a straight line. In such an almost Ricardian model, terms of trade are determined by technical change (see the large values in column 9, Table 4). Changes in endowments (column 13, Table 4) or in demand due to population changes (column 4, Table 6) have little impact on terms of trade. However, such changes influence the output mix and the sectoral allocation of inputs substantially (columns 2, 3, 6 and 7, Table 6).

In Table 5 the signs of the effects of increases in population and labor growth rates are summarized. The combined effect of population growth is the effect of an equiproportional increase in population cum

labor on the variables. This is the "population" effect of the traditional growth models where labor participation rates are constant. Again, all signs are stable between the countries and over time.

Table 5. Signs of Population and Labor Effects.

	Effect on Endogenous Variables							
	Offsetting						Reinforcing	
Exogenous Variable	E	Y <sub>2</sub>	K <sub>1</sub>	K <sub>2</sub>	L <sub>2</sub>	P	Y <sub>1</sub>	L <sub>1</sub>
Population Q	-	-	+	-	-	- <sup>1</sup>	+	+
Labor L	+	+	-	+	+	+ <sup>1</sup>	+	+
Combined Effect of Population Cum Labor Growth	-	+	+	-	+	+	+	+

1. With some exceptions, but with values close to zero.

Labor growth adds to per capita income while population growth reduces it. Because of diminishing returns to labor the combined effect is negative. The magnitudes of the income effects are shown in Table 6.

A one percent rise in the population growth rate alone leads to a reduction of the per capita income growth rate of more than one percent in both countries (column 1, Table 6). In the 1880's in Japan this effect was much larger than in the post-World War II period. Population growth is costlier in economic terms the less developed the country. This again



Table 6. Growth Rate Multipliers (GRM) of Population and Labor  
in Japan and the U. S.

10 -Year Span Beginning	Population Effects				Labor Effects				Combined Effect (Constant Labor Participation)			
	(1) EQ	(2) Y <sub>1</sub> Q	(3) Y <sub>2</sub> Q	(4) PQ	(5) EL	(6) Y <sub>1</sub> L	(7) Y <sub>2</sub> L	(8) PL	(9) EQL	(10) Y <sub>1</sub> QL	(11) Y <sub>2</sub> QL	(12) PQL
	<u>JAPAN</u>											
1880	-1.58	.35	-1.41	.03	1.03	.35	1.63	.10	-.55	.70	.22	.13
1890	-1.52	.36	-.94	.05	.98	.31	1.29	.13	-.54	.67	.35	.18
1900	-1.41	.41	-.79	.04	.91	.30	1.20	.12	-.50	.71	.41	.16
1910	-1.31	.46	-.70	.03	.85	.27	1.15	.12	-.46	.73	.45	.15
1920	-1.26	.43	-.50	.01	.82	.28	1.01	.14	-.44	.71	.51	.15
1930	-1.30	.54	-.50	.00	.88	.25	1.02	.09	-.42	.79	.52	.09
1940	-1.23	.57	-.39	-.00	.77	.21	.88	.10	-.46	.78	.49	.10
1950	-1.16	.50	-.35	-.03	.90	.21	1.09	.32	-.26	.71	.74	.29
1960	-1.11	.51	-.20	-.01	.79	.25	.88	.18	-.32	.76	.68	.17
	<u>U. S.</u>											
1880	-1.14	.34	-.33	-.00	.78	.47	.90	-.03	-.36	.81	.57	-.03
1890	-1.16	.42	-.35	-.01	.83	.48	.94	-.12	-.33	.90	.59	-.13
1900	-1.17	.48	-.32	-.00	.79	.37	.89	-.03	-.38	.85	.57	-.03
1910	-1.16	.60	-.30	.01	.74	.21	.84	.12	-.42	.81	.54	-.13
1920	-1.18	.76	-.31	.00	.75	.14	.83	.05	-.43	.90	.52	.05
1930	-1.13	.77	-.25	.01	.69	.09	.77	.20	-.44	.86	.52	.21
1940	-1.14	.77	-.22	.00	.73	.13	.78	.05	-.41	.90	.56	.05
1950	-1.11	.71	-.16	.02	.71	.13	.74	.15	-.40	.84	.58	.17
1960	-1.08	.72	-.13	.04	.70	.11	.74	.28	-.38	.83	.61	.32

EQ, EL: GRM of Population and Labor on per capita income.

Y<sub>1</sub>Q, Y<sub>1</sub>L: GRM of Population and Labor on sectoral outputs.

PQ, PL: GRM of Population and Labor on the terms of trade.

EQL, Y<sub>1</sub>QL, Y<sub>2</sub>QL, PQL: GRM of an equiproportional rise in population cum labor on per capita income, agricultural output, nonagricultural output, and the terms of trade.

is due to the factor market imperfections and the relative sizes of the two sectors. Population growth causes a shift in demand towards agriculture. The resources transferred by this demand shift leave the higher productivity sector. The smaller the high productivity sector, the higher the proportional reduction in per capita income. When labor grows in step with population, the negative effect of population growth is not nearly as large. Column 9, Table 6, shows that with constant labor participation a one percent rise in the population growth rate leads to less than a one-half percent fall in the per capita income growth rate. Again, the negative effect is smaller, the smaller the agricultural sector.

How population affects per capita income depends crucially on the labor participation rate. Japan was fortunate -- its population growth rate during the period was only around one percent. Employment kept pace with this and also grew around one percent, with the rates differing over the short-run. The combined effect, therefore, gives a good picture. Japan's growth was not much affected by population growth. But it is doubtful that employment could have kept pace had population grown at three percent, as it does now in numerous less developed countries. In that case, the combined multiplier would have been somewhere between the GRM of population alone and the GRM of population cum labor.

Population growth alone tends to increase agricultural output at the expense of nonagricultural output (columns 2 and 3, Table 6). The smaller the nonagricultural sector, the higher the cost of population

growth in terms of nonagricultural goods. To accommodate a one percent increase in population growth rates, the growth rate of nonagricultural output would have been reduced by 1.41% in Japan in 1880, but by only .13% in the U. S. in 1960.

Labor growth alone tends to increase output of both goods, but again the income increase is primarily spent on nonagricultural goods (columns 6 and 7, Table 6). For nonagricultural output, population and labor effects are of opposite signs but the labor effect is larger. Therefore, the combined effect of population cum labor on nonagricultural output is positive.

For agricultural output (and agricultural labor) the population and labor effects are reinforcing and the combined effect is, therefore, positive and large. Population and labor growth draw labor into agriculture and increase agricultural output. Population and labor growth have largely opposite effects on agriculture than do the technical changes, which push resources out of that sector.

Terms of trade are little affected by population and labor growth (columns 4, 8 and 12, Table 6). This is contrary to widely held beliefs. Of course, ours is a long-run model. In the short run agricultural output is fairly inelastic and the transformation curve not as flat as in our model.

How much technical change would have been sufficient in the two economies to offset a one percent rise in the population growth rate or a one percent rise in the growth rate of population cum labor? And how

much capital would have been necessary to achieve the same result?

Table 7 shows this.

In both economies nonagricultural technical change would have been the most powerful tool. And as that sector size increases it becomes more powerful. Contrariwise, the necessary increase in agricultural technical change gets larger the smaller that sector becomes.

The additional growth rate of capital needed to affect a rise in the population growth rate is around three percent in both economies and fairly stable (column 3, Table 7). Column 6 (Table 7) illustrates the well known feature of neoclassical models that if the growth rate of capital increases by the same amount as the growth rate of population cum labor, diminishing returns no longer occur and per capita income does not decline.

Overall, the numerical results of Tables 4, 6 and 7 suggest that the economies of Japan and the U. S. have differed much more at the beginning of the period than towards the end. As the agricultural sector declined in Japan, its economy started to behave more like the U. S. economy.

Table 7. Additional Technical Change or Growth of Capital Needed to Offset the Negative Effect of a One Percent Rise in Population Growth Rates

Decade Beginning In	To Offset a Rise in Population Alone			To Offset a Rise in Population Cum Labor		
	(1) T <sub>1</sub>	(2) T <sub>2</sub>	(3) K	(4) T <sub>1</sub>	(5) T <sub>2</sub>	(6) K
	<u>JAPAN</u>					
1880	2.3	1.7	2.8	.8	.6	1.0
1890	2.7	1.6	2.8	1.0	.6	1.0
1900	2.8	1.6	2.9	1.0	.6	1.0
1910	2.7	1.6	2.8	1.0	.6	1.0
1920	3.2	1.5	2.9	1.1	.5	1.0
1930	3.8	1.4	3.1	1.2	.4	1.0
1940	4.4	1.3	2.7	1.6	.5	1.0
1950	3.7	1.4	4.3	.8	.3	1.0
1960	5.6	1.2	3.6	1.6	.4	1.0
	<u>U. S.</u>					
1880	3.2	1.5	3.1	1.0	.5	1.0
1890	3.3	1.4	3.4	.9	.4	1.0
1900	3.5	1.4	3.2	1.2	.5	1.0
1910	3.9	1.3	2.8	1.4	.5	1.0
1920	4.2	1.3	2.7	1.5	.5	1.0
1930	4.7	1.3	2.6	1.8	.5	1.0
1940	5.4	1.2	2.8	2.0	.4	1.0
1950	7.4	1.2	2.8	2.7	.4	1.0
1960	8.3	1.1	2.9	2.9	.4	1.0

#### IV. Implications

The results of the previous section can give us some ideas of relative magnitudes of benefits and resource shifts caused by sectoral technical changes, capital accumulation and growth of population and labor. The signs of the effects are stable, it is the magnitudes which change. Of course, these magnitudes have to be taken with caution given the simplicity of the model and such assumptions as closedness of the economy. Nevertheless, the role played by sector size and market imperfections in determining benefits and sectoral reallocations is quite striking. Clearly sector size is measured more appropriately by sectoral outputs than by sectoral inputs which may give a wrong picture due to market imperfections. The larger the agricultural sector, the bigger the effect of technical change in agriculture on growth of per capita income and on resource reallocation. Also, an economy appears to be more vulnerable to population growth when the agricultural sector is large.

The results discussed in the previous section put the major problem facing countries with large population growth rates in a different light than the usual general equilibrium models do. In such models, because labor is assumed to grow at the same rate as population, the problem created by population increases comes from diminishing returns to employed labor. To offset this tendency it is sufficient to have capital grow at the same rate as population.

To us this seems to place the emphasis wrongly. Diminishing returns are certainly important, but for many of today's LDC's the large population growth rates put pressure on the labor participation rate. If that rate declines, the resulting income loss will be far outweigh the possible losses from diminishing returns. A rapid population growth rate, therefore, not only requires a high investment rate in physical capital to offset diminishing returns but also a vigorous employment policy. To the extent that such a policy requires investment in human capital, the overall physical and human capital requirements to offset the negative effect of population growth is much higher than the one needed just to offset diminishing returns alone.

Technical change has been treated in this model like manna from heaven and thus appears as an extremely powerful tool of economic growth. Of course, technical change requires large investments in research and development. These investments compete with investments in physical and human capital. It is, therefore, likely that a large population growth rate may also lead to smaller rates of technical change because more physical and human capital is needed to accommodate the rising population. These investments may well diminish the amount of resources spent by the economy on technical change.

Technical change, whether it occurs in agriculture, nonagriculture, or in both sectors simultaneously, has been shown to pull resources out of the agricultural sector because the demand for agricultural products is inelastic. Any dynamic agriculture which experiences technical changes

based growth will therefore tend to aggravate employment problems in the urban sector. The faster agriculture progresses, the bigger will be the need for growth in the nonagricultural sector. The tendency of agricultural technical change to push labor out of that sector could be avoided if the country faces an elastic export market for its agricultural product, or if technical change was strongly labor using. Countries which push agriculture should therefore keenly watch export possibilities not only for the foreign exchange which they may provide but also for their potential employment effects.

Labor using technical change in agriculture is also a possibility. But given the high labor intensity of agriculture in most LDC's, it is unlikely that many opportunities for labor-using technical change exist. On the other hand, the LDC's with employment problems have to be extremely careful not to obtain strongly labor-saving technical change. Such technical change in agriculture would enormously increase the labor displacement from the technical change.

The analysis carried out in this paper implies that developing economies with large agricultural sectors and growing populations face a challenging balancing act: They do need rapid technical change based agricultural growth since this is a powerful source of per capita income. But they have to be careful that this technical change is not strongly biased in labor-saving directions. Even if they achieve this, labor is going to be pushed out of the agricultural sector by the technical change.



To accommodate the rising nonagricultural labor force, that sector has to grow rapidly as well through capital accumulation and technical change. In the present time of emphasis on agricultural growth of less developed countries through technical change we cannot afford to neglect the nonagricultural sector.

APPENDIX A: SUMMARY OF NOTATIONS

( $i=1$  denote the agricultural sector and  $i=2$  the nonagricultural sector)

- $a$  = Demand shifter for agricultural products
- $B$  = Land
- $E$  = Real disposable per capita income
- $K_i$  = Sectoral capital stock
- $L_i$  = Sectoral labor inputs
- $m_r$  = Ratio of return to capital in agricultural sector to return in nonagricultural sector
- $m_{K_i}$  = Ratio of capital return to its marginal revenue product in each sector
- $m_w$  = Sectoral wage differential
- $m_{L_i}$  = Ratio of labor return to its marginal revenue product in each sector
- $N$  = Nonlabor
- $N_r$  = Ratio of interest rate to marginal revenue product in agricultural divided by comparable ratio for nonagricultural sector
- $N_w$  = Ratio of wage to marginal revenue product in agricultural divided by comparable ratio for nonagricultural sector
- $P_i$  = Price of sectoral outputs
- $P$  = Ratio of price of agricultural products to nonagricultural output
- $P'$  = General price level
- $Q$  = Population
- $r_i$  = Interest rate in each sector
- $T_i$  = Technical change in each sector
- $w_i$  = Wage rate in each sector
- $Y_i$  = Sectoral real output

- $\alpha$  = Labor's share in agriculture
- $\beta$  = Capital's share in agriculture
- $\gamma$  = Labor's share in nonagriculture
- $\delta$  = Capital's share in nonagriculture
- $\lambda$  = Share of income produced in agriculture
- $\eta$  = Price elasticity of agricultural goods
- $\epsilon$  = Income elasticity of agricultural goods
- LTES = Estimates of Long-term Economic Statistics of Japan since 1868  
Ohkawa, et al., editors.
- JSY = Japan Statistical Yearbook
- HSJE = Hundred-Year Statistics of the Japanese Economy (Bank of Japan)

APPENDIX B

Proof of Equation (23)

Suppose the agricultural production function is as follows:

$$Y_1 = T_1 L_1^\alpha K_1^\beta.$$

Therefore,

$$\frac{\partial Y_1}{\partial L_1} = T_1 \alpha L_1^{\alpha-1} K_1^\beta.$$

Thus,

$$\begin{aligned} d(\partial Y_1 / \partial L_1) &= \alpha L_1^{\alpha-1} K_1^\beta dT_1 + T_1 \alpha(\alpha-1) L_1^{\alpha-2} K_1^\beta dL_1 \\ &\quad + T_1 \alpha L_1^{\alpha-1} \beta K_1^{\beta-1} dK_1. \end{aligned}$$

Hence,

$$\dot{\xi}_{L_1}' = \frac{d(\partial Y_1 / \partial L_1)}{(\partial Y_1 / \partial L_1)} = \frac{dT_1}{T_1} + (\alpha-1) \frac{dL_1}{L_1} + \beta \frac{dK_1}{K_1}.$$

In this same way,

$$\dot{\xi}_{K_1}' = \frac{d(\partial Y_1 / \partial K_1)}{\partial Y_1 / \partial K_1} = \frac{dT_1}{T_1} + \alpha \frac{dL_1}{L_1} + (\beta-1) \frac{dK_1}{K_1}.$$

Suppose the nonagricultural production function is as follows:<sup>1/</sup>

$$Y_2 = T_2 L_2^\gamma K_2^\delta$$

Therefore,

$$\partial Y_2 / \partial K_2 = T_2 L_2^\gamma K_2^{\delta-1}$$

---

<sup>1/</sup> In case of C.E.S. production function in nonagricultural sector, see Yamaguchi (1973).

Hence,

$$d(\partial Y_2 / \partial K_2) = \delta L_2^\gamma K_2^\delta dT_2 + \gamma \delta T_2 K_2^\delta L_2^{\gamma-1} dL_2 + \delta(-\gamma) T_2 L_2^\gamma K_2^{\delta-1} dK_2.$$

Therefore,

$$\dot{h}'_{K_2} = \frac{dT_2}{T_2} + \gamma \frac{dL_2}{L_2} + \delta \frac{dK_2}{K_2}.$$

In the same way,

$$\dot{h}'_{L_2} = \frac{dT_2}{T_2} - (1-\gamma) \frac{dL_2}{L_2} + (1+\delta) \frac{dK_2}{K_2}.$$

Therefore,

$$\begin{aligned} \dot{N}'_w - \dot{N}'_r &= \dot{g}'_{L_1} - \dot{h}'_{L_2} - \dot{g}'_{K_1} + \dot{h}'_{K_2} \\ &= -\frac{dL_1}{L_1} + \frac{dK_1}{K_1} + \frac{dL_2}{L_2} - \frac{dK_2}{K_2} \\ &= \dot{K}_1 - \dot{K}_2 - \dot{L}_1 + \dot{L}_2 \end{aligned}$$

Q.E.D.

Proof of equation (25)

What we have to prove is as follows:

$$\dot{P} = \dot{T}_2 - \dot{T}_1 + (\gamma-\alpha) (\dot{L}_1 - \dot{K}_1) + \delta \dot{N}'_r + \gamma \dot{N}'_w.$$

However,

$$P_1 m_{L_1} g'_{L_1} = w_1$$

and

$$P_2 m_{L_2} h'_{L_2} = w_2 = \frac{w_1}{m_w}$$

Therefore,

$$P = \frac{P_1}{P_2} = \frac{w_1 m_w m_{L_2} h'_{L_2}}{m_{L_1} g'_{L_1} w_1} = \frac{m_w m_{L_2} h'_{L_2}}{m_{L_1} g'_{L_1}} = N_w \frac{h'_{L_2}}{g'_{L_1}} = N_w \frac{\gamma T_2 (K_1/L_2)^{1-\gamma}}{\alpha T_1 (K_1/L_2)^{1-\alpha}}$$

and

$$\begin{aligned} \dot{P} &= \dot{P}_1 - \dot{P}_2 = \dot{T}_2 - \dot{T}_1 + (1-\gamma) (\dot{K}_2 - \dot{L}_2) - (1-\alpha) (\dot{K}_1 - \dot{L}_1) + \dot{N}_w \\ &= \dot{T}_2 - \dot{T}_1 + (\gamma-\alpha) (\dot{L}_1 - \dot{K}_1) + \delta \dot{N}_r + \gamma \dot{N}_w. \end{aligned}$$

Q.E.D.

APPENDIX C: DATA

Explanations For The Individual Columns In Table 2

JAPAN

(1) Labor's share in agriculture

Labor's share in agriculture was recalculated from the data in the appendix of Yamada and Hayami (1972) to fit the factor definitions used here.

(2) Capital's share in agriculture

Capital's share in agriculture was obtained by subtracting labor's share in agriculture from 1.00.

(3) and (4) Labor and capital's share in nonagriculture

The nonagricultural factor share was developed by Sato (1968). The share after 1930 is calculated by taking the five-year's average centering the years shown on page 279 of Sato. Unfortunately, no data could be obtained before 1930. Therefore, we assumed that labor's share in nonagriculture was 70% and capital's share was 30%.

(5) and (6) Price and income elasticities of agricultural goods

Kaneda (1968) recalculated the earlier work of Nakayama (1958) and Noda (1963). He found that income elasticities estimated by Nakayama should be 0.32 and Noda 0.50 instead of approximately 0.80 from 1878-1922. We adopted 0.40 as the income elasticities of this period.

Kaneda obtained income elasticities of 0.494 for March 1921, 0.386 for 1926/27, 0.347 for 1931/32, and 0.329 for 1935/36. Income elasticities

of 0.45 for the 1920's and 0.35 for the period 1930-1945 were, therefore, used.

With respect to the income elasticities of the post-World War II years, Kaneda obtained 0.481 for 1953, 0.456 for 1957, and 0.472 for 1961 for urban workers' households and around 0.530 for farm households. Independently, Yuize (1964) obtained the value of 0.455 for the period 1956-1962. Therefore, the income elasticity of the postwar years was set at 0.45. Kaneda obtained -0.762 as the price elasticities for the postwar years for urban workers' households and -0.172 for farm households. Yuize obtained price elasticities of -0.696. The price elasticity was set at -0.60 for the postwar years.

With respect to pre-World War II, published sources are not available. However, the Japanese income elasticities were almost constant over the whole period. Therefore, price elasticities were also held constant at -0.60 for the pre-World War II period.

(7) and (9) Proportion of total labor and share of income produced in agriculture.

The total of agricultural labor is obtained from column (3) of Table 33, p. 218, in LTES, Vol. 9. Total labor data come from HSJE, p. 56. From these two data series the proportion of total labor in agriculture can be obtained. First, we can obtain the total national income from HSJE. We also obtain the value of agricultural output from LTES. Therefore, we can obtain the share of income from them.

(8) Proportion of total capital in agriculture.

Since in these international comparisons only two inputs (capital (K)



and labor (L)) in our agricultural production function were assumed, it is necessary to include the land value in the agricultural capital.

Therefore, the arable land (column (14) of Table 32, p. 216, LTES, Vol. 9) was multiplied by 0.0269 million yen (the price of land (100 cho) in 1935) and added the value to net agricultural capital (column (12) of Table 3, p. 154, LTES, Vol. 3 or column (8) of Table 29, p. 212, LTES, Vol. 9) and net total capital (the second column from the last of Table 1, p. 149, LTES, Vol. 3). Thus, the data of agricultural and total capital including the value of agricultural land were obtained.

The proportion of total capital in agriculture can be obtained from these two series until 1940.

Total capital data after 1940 can only be obtained from Reference Table 3 in LTES, Vol. 3. However, this is the value in 1960 prices. Therefore, it is necessary to recalculate into the values of 1934-36 prices. In addition, total capital is measured in gross terms instead of net terms, as used so far. However, the growth rates of gross and net capital stock do not differ very much.

Thus, the total gross capital in 1939 in Reference Table 3 in LTES, Vol. 3 is compared with that of 1950, obtaining a value 1.2 times larger in 1950 than 1939, likewise, 2.0 times greater in 1960 than 1939. Hence, the value of net total capital (the second column from the last of Table 1, p. 149, LTES, Vol. 3) in 1950 and 1960 were multiplied by 1.2 and 2.0 to get the value of net total capital in 1950 and 1960, respectively.

As for agricultural capital and land value, the data after 1940 are available. Therefore, the proportion of total capital in agriculture  $K_1/K$  can be measured.

U.S.A.

(1) and (2) Labor's and capital's shares in agriculture.

Labor's share in U. S. agriculture was obtained from p. 49 of MacEachern (1964), who reports the estimates of King, Johnson and Purdue University in his Figure 1. King's labor share for 1880, 1890, and 1900, Johnson's 1910, 1920, and 1940, and Purdue's for 1950 and 1960 were adopted.

(3) and (4) Labor's and capital's share in nonagriculture.

These are recalculated from Sato's work (1968). He does not have data before 1909. A labor share's constancy before 1909 was assumed.

For the share after 1909, the five years' average, centering the year shown, were used.

(5) and (6) Price and income elasticities of agricultural goods.

Jüreen (1956) gives a table of prewar and postwar income elasticities at varying income levels.

From this table, the income elasticities for each period were obtained, if per capita income was known. The results show that the income elasticity was 0.29 in 1880 and 0.25, 0.23, 0.17, 0.12, 0.12, 0.12, 0.15, 0.15, and 0.15 in 1890, 1900, 1910, 1920, 1930, 1940, 1950, 1960, and 1970, respectively.

However, Brandow (1961) shows an income elasticity for agricultural goods for 1950-60 of around 0.25-0.30. Tolley-Smidt (1964) also adopted an income elasticity for agricultural goods of 0.25. The values of Jüreen are obtained from the multi-country curves. Therefore, it was

assumed that the U.S. economy had higher income elasticities for each per capita income than in the usual case. Therefore, Jureen's values for each year were multiplied by 1.5 or 2.0 to obtain the values of Table 3.

For consistency, price elasticities are assumed to be slightly higher than income elasticities, as for the Japanese economy.

(7) and (8) Proportion of total labor and capital in agriculture.

These values are obtained from Kendrick (1961) in the last three column of Table A-VI, p. 305.

Real farm capital stock and the summation of this real farm capital stock plus real private nonfarm nonresidential capital stock comes from his Table A-XV, p. 320.

(9) Share of income produced in agriculture.

Column (1) and (8) of Table A-III, p. 289, of Kendrick (1961) reports these values.

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FOOTNOTES

- 1/ In Yamaguchi (1973), because the categories of goods have different production functions, and demand functions for the corresponding income recipient differ, each sector is further divided into a consumption goods sector and a capital goods sector. Therefore, the whole economy produces four different products. In the Kelley and Williamson (1972) and an earlier model of Yamaguchi (1969), the whole economy produces three products, namely, agricultural consumption goods, nonagricultural consumption goods, and nonagricultural capital goods. However, the agricultural sector also produces agricultural capital goods such as cattle, fruit trees, etc., which is a justification for a four sector model.
- 2/ Note that we separate population (Q) and the demand shifter (a). The demand shifter, therefore, captures changes in tastes which cannot be linked to prices, income, or population.
- 3/ Other papers report empirical work using our model. (1) Multiplying the growth rate multipliers of each decade by the corresponding decadal rates of change of the exogenous variables gives measurements of the contribution of the exogenous variables to the observed rate of changes of the endogenous variables. (2) Simulations are performed with different assumptions about the rates of technical change and of population growth, i.e., changing the value of the element of vector b and observing the change of the elements of vector x, i.e., endogenous variables (See Yamaguchi (1974) and Yamaguchi and Binswanger (1974)).
- 4/ Generally, the signs apply to both economies and all decades, with a few exceptions. (However, the values of the exceptions are almost zero.)
- 5/ Multiplying the growth rate multipliers of each decade by the corresponding decadal rates of change of the exogenous variables gave the measurements of the contribution of the exogenous variables to the observed rate of change of the endogenous variables. (See Yamaguchi (1973, 1974b), Yamaguchi and Binswanger (1974a, b)).