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Returns to Scale in Japan: An Empirical Analysis of the Dynamic Production Function

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I. Introduction

In recent years, the notion of increasing returns has played an important role in the study of economic growth. Romer (1986) and Lucas (1988) emphasized the role of increasing returns as an aggregate production function. In their "new" growth models,[1] economies reach different steady-states because of differences in initial endowments or in the accumulation of tangible and/or intangible capital. This key result differs from Solow's neo-classical growth model in that, according to the latter, economies converge in one steady state regardless of initial endowments.

On the other hand, the positive correlation between the openness of international trade and the rate of growth has been stressed by many authors, such as Edwards (1989), and Sengupta (1993). Openness to international trade, for which in the volume of international trade can be a proxy, is expected to cause non-decreasing returns. In this vein, the Romer-Lucas result has been used to explain, in part, the international divergence in the rates of economic growth. Another implication of the "new" growth models is that the rapid expansion of an economy is due to relatively large increases in intangible capital. This phenomenon was observed in the NICs and in Japan. Furthermore, the expansion of these economies has been strongly influenced by a notable increase in the exports of manufactured products, and the expansion of trade has contribute to the acquisition of intangible capital through learning-by-doing.[2]

The key conclusion of the "new" growth theory has been well studied, (particularly the type of model proposed by Romer); however, the empirical studies for the theory are so far inconclusive. For example, Barro (1990) studied the correlation between initial endowments and the rates of growth using cross section data drawn from

[1] To avoid confusion, the term "new" growth model will be used to indicate the Romer-Lucas models.

[2] Krugman (1989) developed a model in which an economy increases its intangible capital by imposing trade restriction. In his model, because of the restrictions, the economy can acquire experience in producing certain products, such as manufacturing products, thereby endogenizing the comparative advantage in such products.

Summers and Heston (1988). His study discovered that the growth rate of output per capita correlates positively with the initial level of endowments, and that is supports the assumption of increasing RTS. However, the study done by Mankiw, Romer and Weil (1992) used the same sources of cross section data as Barro and they argued that Solow's neo-classical growth model with augmented capital and labor, is quite satisfactory for explaining the international variation of the standard of living. A common feature of these empirical studies is that they assume that all of the countries in their samples have reached the steady-state and that their economies do not face any cost in adjusting to such states. These assumptions allow them to examine the cross-sectional regressions.

In addition, as Krugman (1990) demonstrated, the path of economic expansion may be influenced by the behavior of the economic agents in regard to the future or the past. Particularly, when the production process is subject to adjustment costs, the agent's behavior (consequently the steady-state) is strongly influenced by the structure of the Expectation formation. In this vein, the cross sectional studies in which each economy is assumed to reach a unique steady-state may have ignore that the steady state under the examination could be conditional on the outlook of the agent in each economy.

This paper attempts to evaluate the returns to scale property of the aggregate production function, and seeks to uncover the source(s) of the "non-decreasing" property of inputs. To this end, the model of adjustment cost is employed, explicitly allowing the dynamic feature of the growth process. A partial equilibrium framework is employed in which output is determined solely by the producer. The final good is produced using two inputs, labor and capital. The model proposed by Kennan (1979) is utilized to estimate the parameters of the production function, the speed of adjustment coefficients, and the relative importance of the inefficiency and adjustment costs. The decision making process is subject to disturbances such as difficulties in implementing planned targets. Consequently, aside from input cost, the producer faces two types of costs, (i) an inefficiency cost and (ii) an adjustment cost. The inefficiency cost refers to the additional cost incurred as a result of deviating from the target efficiency level of input usage. The adjustment cost refers to costs of moving toward the optimal input combinations. To simplify the derivation of estimable equations, no substitution effect between inputs is assumed in adjustment and dis-equilibrium costs. The estimation process involves two steps. First, the speed-of-adjustment coefficients are estimated to provide a framework for analyzing the stability of the system. To incorporate the view of producers in the decision making, the first step could be specified as either *backward-looking* or *forward-looking*. Using the estimated speed of adjustment parameters from the first step, second step equations are estimated. Then deep parameters are computed from the estimated parameters of the second equation to characterize the optimal growth path and to estimate the underlying production function. Time series data from Japan spanning the years 1965 and 1990 are used.

Four different specifications of the production function are used and, for each specification, there is a corresponding adjustment rule for each input. The specifications differ in the choice of output variable, that is GNP or GDP; and in the inclusion or exclusion of external effects. The external effects are captured by exports.[3]

For all specifications, the first step is estimated by OLS. The second step is estimated by OLS and SUR. Six key results are obtained form the estimations. (1) The model without external effects exhibits unreasonably high returns to scale. (2) The estimated characteristic roots under forward-looking agent show that the system is clearly stable; while the estimated characteristic roots show that the system could be explosive under backward specification. (3) The significance and signs of the labor coefficient, capital coefficient and coefficients of external effects are the same under the both behavioral assumptions. (4) Qualitatively, the sign and significance of the input and external coefficients are identical under both estimation methods. However, the application of SUR for the forward looking model reduced the scale of the elasticity of capital inputs. (5) Labor is the more significant input in that the output elasticity of labor is greater than that of capital in absolute value, and (6) External effects are probably transmitted by labor inputs rather than the capital inputs.

II. The Model

We focus on the behavior of the producers, and assume that the slow process of growth is due to adjustment costs associated with shifting of input levels. Even though the models of growth analyze the path of an economy in general equilibrium models, it is possible to break the problem into two parts[4], namely the problems of consumer and producer. In the growth models, contrary to the problem of the consumer, the producer's optimal path is determined by the static profit maximization problem. Therefore, the dual problem, the cost minimization problem, determines the targeted level of inputs. This assumption implies that at each moment in time, the producer can achieve the efficient levels of input. However this instantaneous adjustment is unlikely to be fulfilled. In the each moment in time, because of uncertainty in the exogenous variables and some fixity in the input mobility, it is more appropriate to assume inefficiency in the observed input levels.[5] In addition to these two sources, under the existence of external effects, the producer may not realize the extent of the effect immediately.[6]

The Kennan model (1979) used here incorporates the sources of inefficiencies by

[3] In the development literature, exports are included in the specification of a production function to study the effects of international trade on the growth of the economies. [See Feder (1982), Riedel (1984), and Chow (1987) for example.]

[4] See Blanchard and Fischer (1989) in Chapter 2 or Sala-i-Martin (1990).

[5] See Oi (1962).

[6] Hall (1990) claimed the sources of short-run pro-cyclicality in productivity is partly due to the firm-level externality as well as pro-cyclical productivity shock and quasi-fixity of the inputs.

assuming that the producer minimizes a loss function. This function comprises the costs of deviating from the efficient input levels (also called inefficiency or dis-equilibrium costs) and the adjustment costs.[7]

(1) Equilibrium Path

As suggested in neo-classical models, it is assumed that the producer of the economy chooses his targeted level of input demands by minimizing a static cost function.

(Problem 1)[8]

$$\text{Min } \omega_t L_t + \phi_t K_t \tag{1}$$

Subject to

$$Q_t = B\,(A_t, V_t)\,K_t^{a}\,L_t^{b} \tag{2}$$

where Q_t is output, L_t is labor, K_t is capital services ω_t and ϕ_t are respective prices of these inputs. B is the technological coefficient. The technological coefficient is a function of exogenous technological shock A_t and an external variable V_t which could be either exogenous or endogenous. When V_t is endogenous, its level is dependent on the choice variable of the economy.

Allowing for stochastic trends, optimal levels of input are subject to white noise processes. Then the first order condition flowing from equation (1) and (2) can be expressed as:

(F.O.C.1)

$$\ln L_t^* = \ln(a/b)^{\frac{a}{a+b}} + \left(\tfrac{1}{a+b}\right)\ln B_t(A_t, V_t) - \left(\tfrac{a}{a+b}\right)\ln\left(\tfrac{\omega_t}{\phi_t}\right) + \left(\tfrac{1}{a+b}\right)\ln Q_t + \varepsilon_L \qquad \text{(3)-L}$$

$$\ln L_t^* = \ln\left(\tfrac{a}{b}\right)^{\frac{a}{a+b}} + \left(\tfrac{1}{a+b}\right)\ln B_t(A_t, V_t) - \left(\tfrac{b}{a+b}\right)\ln\left(\tfrac{\omega_t}{\phi_t}\right) + \left(\tfrac{1}{a+b}\right)\ln Q_t + \varepsilon_K \qquad \text{(3)-K}$$

where ε_L and ε_K represent white noise disturbances for labor and capital respectively. The producer target levels of input in each period of time satisfy the first order conditions in (3).

(2) Feasible Input Demand and Estimable Equations

Although the target level is the determined by the efficiency condition (3), in

[7] The use of the adjustment cost model to evaluate the growth process follows Krugman (1990), which has suggested that the process of the intangible capital acquisition depends upon the s economic agent's expectations.

[8] This is the Marshallian assumption of the competitive firm under externality. (See Sala-i-Martin. (1990)) This means that the producer of the economy is not aware of the externality.

short-run, the producer must face disequilibrium and adjustment cost in each period. Consequently, he faces the following cost minimization problem.
(Problem 2)

$$\underset{X_t}{Min}\, E_t \sum_{t=0}^{t=\infty} R^t \left[(X_t - X_t^*) \Lambda (X_t - X_t^*)' + (X_t - X_{t-1}) \Psi (X_t - X_{t-1})' \right] \tag{4}$$

where R is the rate of interest, $X_t = (\ln K_t, \ln L_t)$ is the vector of actual level of inputs, and $X_t^* = (\ln K_t, \ln L_t)$ is the vector of target level of the inputs determined by the (F.O.C.1).[9] Finally, Λ and Ψ are the 2×2 matrix of weights of the dis-equilibrium and adjustment costs respectively. These are:

$$\Lambda = \begin{pmatrix} \Lambda_L & 0 \\ 0 & \Lambda_K \end{pmatrix} \quad \text{and} \quad \Psi = \begin{pmatrix} \Psi_L & 0 \\ 0 & \Psi_K \end{pmatrix}$$

Since, by assumption, there is no input substitutions, the weight matrices are diagonal.[10] The optimization in **(Problem 2)** can be separated into two minimization problems, in which input demands are obtained separately. Then, the first-order-conditions for the problem in (4) above can be expressed as the system of two equations given by:
(F.O.C.2)

$$\Lambda_L \left(\ln L_t - E_t (\ln L_t^*) \right) + \Psi_L (\ln L_t - \ln L_{t-1}) - R \Psi_L (\ln L_{t+1} - \ln L_t) = 0 \tag{5)-L}$$

$$\Lambda_K \left(\ln K_t - E_t (\ln K_t^*) \right) + \Psi_K (\ln K_t - \ln K_{t-1}) - R \Psi_K (\ln K_{t+1} - \ln K_t) = 0 \tag{5)-K}$$

Since equations (5)-L and (5)-K take the same form, it is sufficient to analyze the labor equation.

Rearranging (5)-L gives:

$$\theta_L E(\ln L_t^*) = (\theta_L + 2) \ln L_t - \frac{1}{R} \ln L_{t-1} - \ln L_{t+1} \tag{6}$$

where

$$\theta_L = \frac{\Lambda_L}{\Psi_L} \tag{7}$$ [11]

The ratio of weights of dis-equilibrium and adjustment costs, θ_L, measures the relative importance of inefficiency and adjustment cost.

Applying lag-operator, Z, to the right hand side of the equation (6) gives:

$$-\theta_L E_t (\ln L_t^*) = \left[-(\theta_L + 2) Z + Z^2 + 1 \right] \ln L_{t+1} \tag{8}$$

[9] Following Callen, Hall and Henry (1990), R is assumed to be unity.
[10] The assumption of independence is commonly adopted by empirical works. See for example. Nadiri and Rosen (1969).
[11] It is assumed that the target level of the inputs are only variables which is subject to stochastic disturbances.

Let ξ_1 be the non-explosive root of the quadratic equation of lag-operators in (8). Through a series of manipulations, it is possible to derive the expression (9) from equation (8).[12] That expression is:

$$(1-\xi_1 \ Z)\ln L_{t-1} = (1-\xi_1)d_t^L \qquad (9)$$

The term d_t^L is called desired level of labor input and is defined as

$$d_t^L = (1-\xi_1)\sum_{s=0}^{s=\infty}\xi_1^s \ln L_{t+s}^* \qquad (10)$$

Define $N_L = 1-\xi_1$ (11)

By subtracting $\ln L_{t-1}$ from equation (8), the partial adjustment rule for labor is obtained.

$$\Delta \ln L_t = N_L\,(d_t^L - \ln L_{t-1}) \qquad (12)\text{-L}$$

Doing likewise for capital input gives:

$$\Delta \ln K_t = N_K\,(d_t^K - \ln K_{t-1}) \qquad (12)\text{-K}$$

In addition, the relationship between speed of adjustment parameter, N, and parameter of the relative importance of the cost, θ, can be derived. This is:

$$\theta_i = -N_i R + \left(N_i/(1-N_i)\right), \text{ where } i = L,\ K. \qquad (13)$$

The equation (5)-L and (5)-K also imply equation (14) below. Assuming perfect foresight, substituting equation (4) into (7), and taking one lag backward gives:

$$Y_t^L = -\theta_L\left[\ln(a/b)^{-\frac{a}{a-b}} + h_B \ln B_t(A_t, V_t) + h_{(\omega/\phi)}^L \ln(\omega_t/\phi_t) + h_Q \ln Q_t\right] \qquad (14)\text{-L}$$

$$Y_t^K = -\theta_K\left[\ln(a/b)^{-\frac{a}{a+b}} + h_B \ln B_t(A_t, V_t) + h_{(\omega/\phi)}^K \ln(\omega_t/\phi_t) + h_Q \ln Q_t\right] \qquad (14)\text{-K}$$

where

$$Y_t^L = \ln L_t - (\theta_L + R + 1)\ln L_{t-1} + \ln L_{t-2} \qquad (15)\text{-L}$$

$$Y_t^K = \ln K_t - (\theta_L + R + 1)\ln K_{t-1} + \ln K_{t-2} \qquad (15)\text{-K}$$

[12] Please see Kennan (1979) or Okamura (1994) for details.

The coefficients of (14) are:

$$h_B = 1 / a+b, \quad h_Q = 1 / a+b$$

$$h^K_{(\omega/\phi)} = b/_{a+b} \cdot \quad \text{and} \quad h^L_{(\omega/\phi)} = -a/_{a+b}$$

So if we can find the estimates of N's in (12), we can calculate θ. Then the h's can be exactly identified by estimating (14).

(3) Formulation of External Effects

Thus far, external effects have not been included in the production function. However, input demand may be affected by such external effects through the technological innovation represented by variable B.[13] For the sake of simplicity, B is defined as the multiplicative function of exogenous technological shock, A_t, and the external variable V_t. Hence,

$$B(A_t, V_t) = A_t V_t^{\gamma_K + \gamma_L} \tag{16}$$

where γ_K is the external effect of V_t on the capital input, and γ_L is the effect on the labor input. Assuming that external effects on inputs are independent, the estimated input coefficients will segregate the external effects through each input.[14] If the producer does not internalize the increase in the efficiency due to external effects, V_t is treated as exogenous. In this case, $\ln B_i$ becomes $\ln A_t + \gamma_i \ln V_t$ where $i = K, L$. Then equation (5)-L and (5)-K will now include V_t in exactly same way as the other exogenous variables, and the coefficients of $\ln V_t$, γ_i $i = K, L$, measure the impact of the external variable on input demands.

III. Estimation

(1) Two Step Procedure and Specifications of Agent's Behavior

The model is estimated in two steps. In the first step, the speed of adjustment parameter N_i (i=K, L) are estimated. Equations (12)-L and (12)-K give the estimable form:

$$\Delta \ln K_t = -N_K \ln K_{t-1} + N_K d_t^K + \upsilon_t^K \tag{17)-K}$$

[13] In this paper, exogenous export demand is assumed to be one of such variables.

[14] This is a variation of production function in Stiglitz (1990). In his production function, K and L directly included as external variables. The use of export as an external variable is an adaptation of the model by Feder (1982).

$$\Delta \ln L_t = -N_L \ln L_{t-1} + N_L d_t^L + \upsilon_t^L \quad (17)\text{-L}$$

where υ are white noise process.[15]

As in (18), the term $N_i d_t^i$ involves infinite summation of all future target level of input. If appropriate proxies for $N_i d_t^i$ are found, the speed of adjustment parameters, N_i, can be directly estimated from (17)-L and (17)-K. Then, substituting estimates of N_i into (11) and (13), the (stable) root of the system and the relative importance of dis-equilibrium and adjustment cost, θ_i, $i=K, L$, are computed. Since the error terms in (17) are white noise, the OLS estimates for N_i are consistent.

Two different approximations for $N_i d_i^i$ are made here. In the first approximation $N_i d_t^i$ is expressed as a linear function of current and past values of exogenous variables. That is:

$$N_i d_t^i = \sum_{t=0}^{t=3} \left(a_s \ln(\omega/\phi)_{t-s} + b_s \ln Q_{t-s} + \gamma_s \ln V_{t-s} \right) \quad (18)$$

This model is called the backward-looking model.

In the second approximation, $N_i d_t^i$ is expressed as a linear function of current and future values of exogenous variables. That is:

$$N_i d_t^i = \sum_{t=0}^{t=3} \left(a_s \ln(\omega/\phi)_{t+s} + b_s \ln Q_{t+s} + \gamma_i \ln V_{t+s} \right) \quad (19)$$

This model is called the forward-looking model.

Recalling that $d_t^L = (1-\xi_1) \sum_{s=0}^{s=\infty} \xi_1^s \ln L_{t+s}^*$, this term incorporates the explosive root of the system.

(2) Specification of the Production Functions and Endoginuity of Technological Parameter

The general production function is reproduced below.

$$Q_t = B\,(A_t, V_t)\, K_t^a\, L_t^b \quad (2)$$

The choice of output variable, Q_t and external variable has implications about the exogenity of the external variable V_t, hence the technological parameter B. Four different specifications of equation (2) are used They are:

(S-i) GDP $= AK^aL^b$,
(S-ii) GNP $= AK^aL^b$,
(S-iii) GDP $= AV^{\gamma_K+\gamma_L} K^aL^b$, and
(S-iv) GNP $= AV^{\gamma_K+\gamma_L}K^aL^b$

[15] From equation (11), stochastic error terms associated with d(t) arise from the error terms in (6). Since the error terms are assumed to be white noise in (6), the linear combination of such errors is also white noise.

The dual problem of the cost minimization, problem specified as (Problem 1), is a profit maximization problem in which the producer chooses output, Q. If output is specified as GNP then, by choosing the output level, the producer implicitly chooses the level of exports Vt. Since GNP is the sum of GDP plus exports, the technological parameter is not exogenous to the model. However, if the output variable is GDP, then B is an exogenous parameter.

(3) Data

Returns to scale of the underlying production function, during a rapid expansion period, is estimated using Japanese data. The data covers the period 1965 to 1990. Except for labor data (number of workers, monthly wages, monthly work hours) and capital stock data, all the other data were collected from the *STATISTICAL YEARBOOK OF JAPAN*. Data on output, GDP, GNP and exports, were adjusted for 1985 prices by using the GNP and export deflator respectively. The labor data were drawn from the *BASIC STATISTICAL SURVEY OF WAGE STRUCTURE* (*CHINGINKOZO KIHONTOKEI CHOSA*) and wage levels are expressed in terms of 1985 prices using CPI. Total labor service is a product of the number of workers times total monthly work hours.[16] Capital stock data were collected from *GROSS CAPITAL STOCK OF PRIVATE ENTERPRISES* [17] (*MINKANKIGYO SHIHONSUTTOKU.*). For both labor and capital service figures, it is assumed that the intensity of flow of services was constant for each unit of work or capital stock.

IV. Empirical Results.

(1) First Step Results.

The first step results from estimating the forward-looking and backward-looking models are presented in Table I-F and I-B respectively. From the estimates of the speed-of-adjustment parameter, N, ξ_1's are computed and less than one, indicating the system could be all stable. This means that the inclusion of the proxies for $N_i d_t^i$, in the first step eliminated the unstable part of the system.

However, the roots for the capital, ξ_1^K, are large and closed to one. So, the convergence to the steady-state is slow. In particular, for the backward-looking specification, the estimated values of the speed of adjustment parameters, N_K, are all statistically insignificant. So, under the null hypothesis, $H_0\!:\!N_K\!=\!0$, the estimated roots for capital equals one. Subsequently, the backward-looking approximation for

[16] Institutionally, Japanese firms are reluctant to lay off workers even during recessions. So, the work hours should be close proxy for total effort spent in production.
[17] The capital stock data are available in both progressive and non-progressive bases. For this study, data for the non-progressive base, adjusted for the 1985 price was used.

Table I-B
Summary of the First Step Estimates
: *Nd(t)* = *AR*(3) of Exogeneous Variales

	Output		Input	N	Characteristic root	θ
i	GNP (DEF)	—	K	0.055*	0.945	0.003
			L	0.937	0.063	13.944
ii	GDP (DEF)	—	K	0.120*	0.88	0.016
			L	0.936	0.064	13.687
iii	GNP (DEF)	EX	K	0.118*	0.882	0.016
			L	0.898	0.102	7.873
iv	GDP (DEF)	EX	K	0.120*	0.88	0.016
			L	0.924	0.076	11.231

Table I-F
Summary of the First Step Estimates
: *Nd(t)* = *AR*(3) of Exogeneous Variales

	Output		Input	N	Characteristic root	θ
i	GNP	—	K	0.132	0.868	0.0202
			L	0.811	0.189	3.489
ii	GDP	—	K	0.140*	0.860	0.0227
			L	0.888	0.112	7.008
iii	GNP	EX	K	0.082	0.918	0.0073
			L	0.837	0.163	4.2807
iv	GDP	EX	K	0.086	0.914	0.0082
			L	0.569	0.431	0.7526

$N_i d_t^i$ may not have successfully eliminated the explosive roots of the system.

Contrary to the results for the capital equations, the results for the labor equations showed significance in the estimated values of N_L, and the calculated values of testable roots are all less than one, implying stability.

(2) Second Step Results from Backward-Looking Model

Despite the fact that the first step estimates for the backward-looking model cast doubts on the stability of the system, the second step equations (14)-L and (14)-K are estimated based on the estimates of θ in Table I-B. The results are reported in Table II-B-OLS and Table II-B-SUR.

There is little difference between the OLS estimates and SUR estimates.

Estimated Parameters associated with elasticity of inputs, $\hat{h}^{L}_{(\omega/\phi)}$, $\hat{h}^{K}_{(\omega/\phi)}$, and the parameters associated with the effects of export on labor demand, $\hat{h}^{L}_{Y}$, are significant or weakly significant. However, the estimated parameter associated with effects of export on capital demand, $\hat{h}^{L}_{Y}$, are all insignificant. This may indicate that the export effects are not transmitted to capital inputs.

For all specifications, the computed values of the output elasticity of capital, $\hat{a}$'s, are all negative, while the computed parameters of the labor inputs, $\hat{b}$'s, are all positive and much larger than that of the capital in absolute value. Furthermore, the computed values of the external effects on capital, $\hat{\gamma}_K$, is negative while that on labor, is postive. These results and insignificance of $\hat{h}^{K}_{(\omega/\phi)}$, indicate that labor is more important input inn the production than capital and the external effects are morelikely to be carried by labor.

(3) Results for the Forward-Looking Model

The second step results for the forward-looking specifications are reported in Table II-F-OLS and Table II-F-SUR. Under this behavioral assumption, the differences in the OLS estimates and SUR estimates are again little. In addition, the significance and signs of the estimated parameters are almost identical under the backward-looking model. Except for SUR estimates for $\hat{h}^{K}_{(\omega/\phi)}$ in (S-iv), estimated parameters associated with $\hat{h}^{L}_{(\omega/\phi)}$, and $\hat{h}^{K}_{(\omega/\phi)}$, are all significant. The estimates for the effects of export on labor demand, $\hat{h}^{L}_{Y}$, are all significant or weakly significant. However, the estimated parameters associated with effects of exports on capital demand, $\hat{h}^{K}_{Y}$, are all significant. For all specifications, the computed output-elasticities of capital, $\hat{a}$'s, are again all negative, while the computed output-elasticities of labor, $\hat{b}$'s, are all positive and much larger than the these of the capital inputs in absolute value. Furthermore, the computed values of the exports external effects on capital, $\hat{\gamma}_K$, are negative for (S-iii) and positive for (S-iv). And the effects of exports on labor, $\hat{\gamma}_L$, are all positive. the quantity of effects on exports on capital is much smaller than their effects on labor in absolute value. These results and the insignificance of $\hat{h}^{L}_{Y}$, indicate that labor is a more important inputs in production than capital, and the external effects are more likely to be caused by labor.

(4) Comparison of the Backward-Looking and Forward-Looking Specifications

Under both behavioral specifications, the labor coefficients are positively significant, and the magnitudes are greater than that for capital. Moreover, the coefficients of export effects on labor demand are all positive and significant. consequently, labor is more important input than capital, and external effects are primarily transmitted by labor.

On the other hand, under both specifications, the computed coefficients of capital

Table II-B-OLS

Results for the Second Step when $d(t) = AR(3)$

Output	Input	Estimated Parameters					Parameters of the model					
		Const	$\frac{1}{a+b}$	$\frac{b}{a+b}$	$\frac{a}{a+b}$	$\frac{-\gamma}{\alpha+\beta}$	$a+b$	b	a	γ	RTS†	R^2
i GNP —	K	12.90*	0.276	1.371	−0.371		3.63	4.98	−0.51		3.63	0.015
	L	16.35										0.600
ii GDP —	K	12.67*	0.282	1.356	−0.356		3.54	4.81	−0.48		3.54	0.109
	L	16.38										0.598
iii GNP EX	K	4.426	1.248	1.139	−0.139	0.264	0.80	0.91	−0.16	−0.21	1.44	0.242
	L	12.09				−0.483						0.648
iv GDP EX	K	6.04*	0.929	1.167	−0.167	0.43*	1.08	1.26	−0.2	−0.46	1.42	0.250
	L	13.69				−0.314				0.34		0.639

* Not significant at 10% significance level.

** Not significant at 5% significance level and significant at 10% significance level.

† Returns to scale = $a + b + \gamma_i$ $if(\gamma_i + \sum\alpha)$ is statisticaly significant.

$h_Q = 1/a + b \quad h^K_{(\omega\phi)} = -b/a + b$ *and* $h^L_{(\omega\phi)} = a/a + b$

Table II-B-SUR

Results for the Second Step when $d(t) = AR(3)$

Output	Input	Estimated Parameters					Parameters of the model					
		Const	$\frac{1}{a+b}$	$\frac{b}{a+b}$	$\frac{a}{a+b}$	$\frac{-\gamma}{\alpha+\beta}$	$a+b$	b	a	γ	RTS†	R^2
i GNP —	K	12.83*	0.278	1.388	−0.388		3.6032	5	−0.538		3.6032	0.0158
	L	16.28										0.600
ii GDP —	K	12.53*	0.295	1.369	−0.369		3.3842	4.633	−0.505		3.3842	0.112
	L	16.23										0.598
iii GNP EX	K	4.346	1.249	1.16	−0.16	0.263*	0.8004	0.929	−0.186	−0.21	1.434	0.242
	L	12.01				-0.483				0.634		0.648
iv GDP EX	K	6.009*	0.923	1.185	−0.185	0.432*	1.0831	1.284	−0.22	−0.468	1.4211	0.250
	L	13.66				−0.31**				0.338		0.638

* Not significant at 10% significance level.

** Not significant at 5% significance level and significant at 10% significance level.

† Returns to scale = $a + b + \gamma_i$ $if(\gamma_i + \sum\alpha)$ is statisticaly significant.

$h_Q = 1/a + b \quad h^K_{(\omega\phi)} = -b/a + b$ *and* $h^L_{(\omega\phi)} = a/a + b$

Table II-F-OLS

Results for the Second Step when $d(t) = AR(3)$

Output	Input	Estimated Parameters					Parameters of the model					
		Const	$\frac{1}{a+b}$	$\frac{b}{a+b}$	$\frac{a}{a+b}$	$\frac{-\gamma}{\alpha+\beta}$	$a+b$	b	a	γ	RTS†	R^2
i GNP(DEF) —	K	12.5*	0.274	1.415	−0.415		3.6518	5.1669	−0.587		3.6518	0.139
	L	16.21										0.463
ii GDP(DEF) —	K	12.61	0.282	1.37	−0.37		3.5487	4.8625	−0.507		3.5487	0.155
	L	16.33										0.552
iii GNP(DEF) $^{EX(PEX)}$	K	3.331*	1.395	1.124	−0.124	0.276*	0.7167	0.8054	−0.139	−0.198	1.1047	0.085
	L	12.01				−0.557				0.388		0.592
iv GDP(DEF) $^{EX(PEX)}$	K	−1.23*	2.388	0.983	0.017	−0.198*	0.4187	0.4117	0.0166	0.083	0.8487	0.099
	L	6.80**				−1.026**				0.430		0.271

* Not significant at 10% significance level.
** Not significant at 5% significance level and significant at 10% significance level.
† Returns to scale = $a + b$ + significant value of γ.
$h_Q = 1/a+b$ $h^K_{(t,\phi)} = {-b}/a+b$ *and* $h^L_{(t,\phi)} = {a}/a+b$

Table II-F-SUR

Results for the Second Step when $d(t) = AR(3)$

Output	Input	Estimated Parameters					Parameters of the model					
		Const	$\frac{1}{a+b}$	$\frac{b}{a+b}$	$\frac{a}{a+b}$	$\frac{-\gamma}{\alpha+\beta}$	$a+b$	b	a	γ	RTS†	R^2
i GNP(DEF) —	K	12.19*	0.305	1.434	−0.434		3.2808	4.7036	−0.622		3.281	0.148
	L	15.91										0.458
ii GDP(DEF) —	K	12.39	0.306	1.38	−0.38		3.2648	4.505	−0.524		3.2648	0.162
	L	16.11										0.549
iii GNP(DEF) $^{EX(PEX)}$	K	3.233*	1.396	1.151	−0.151	0.2752*	0.7161	0.8245	−0.174	−0.197	1.1071	0.085
	L	11.27				−0.5579				0.391		0.592
iv GDP(DEF) $^{EX(PEX)}$	K	−1.29*	2.316	1.111*	−0.111	−0.1655*	0.4317	0.4797	−0.124	0.071	0.8607	0.100
	L	6.747**				−0.994**				0.429		0.270

* Not significant at 10% significance level.
** Not significant at 5% significance level and significant at 10% significance level.
† Returns to scale = $a + b$ + significant value of γ.
$h_Q = 1/a+b$ $h^K_{(t,\phi)} = {-b}/a+b$ *and* $h^L_{(t,\phi)} = {a}/a+b$

are negative. the negativity of the capital share raises a serious question abut the underlying production process. At first sight, it implies that the capital inputs may be put in place even thought they may reduce the current production. However, higher expectation about the future, and possibility of substitutions of capital from labor to adjust ahead may explain the negativity also. Similar results are found in a study by Northworthy and Jang (1992).[18] In their explanation, if the cost of one of the inputs is rising rapidly, the firms will substitute other inputs for that input. Subsequently, the substitution would continue even after the productivity of the former becomes negative. The implicit assumption with this over-substitution that the firms expects the former input costs rise and continuously to the future. So the adjustment for the optimal level of inputs takes place before higher costs occur.

The second explanation for the negativity in capital coefficients is structural break-down. If a structural break-down happens during the data period, the trends during the period may not be explained by one set of parameters of the production function. Cheung and Chinn reported that there was structural break-down in the Japanese GDP series between 1950 and 1988.

(5) Returns to Scale

To compute returns to scale, the computed values of $\hat{a}$ and $\hat{b}$ are added for specification (S-i) and (S-ii). For (S-iii) and (S-iv), $\hat{a}$, $\hat{b}$, and $\hat{\gamma}_L$ are summed. The computed values of $\hat{\gamma}_K$, s are excluded from the calculation of returns to scale because of the insignificance of $\hat{h}^K_{(\omega/\phi)}$. For all specifications and estimation methods, the specification (S-i) and (S-ii) yield very large returns to scale [range between 3.28 and 3.65].

This inclusion of exports in specification (S-iii) and (S-iv) reduces returns to scale by a notable amount. Under these specifications, the computed values of returns to scale are greater than one for all estimation under the backward-looking model. The values of returns to scale are less than one for the GDP equation under the forward-looking model. These results indicate that when the technological parameter, B, is treated as exogenous, the underlying production function may exhibit decreasing returns to scale. When B is endogenous, the underlying production function exhibits increasing returns to scale.

Furthermore, for (S-iii) and(S-iv), the null hypothesis:

$$H_0 : a + b + \gamma_L = 1$$

is tested by using Wald's test. The test statistics are shown in Table III-B and III-F.

[18] Northworthy and Jang (1992) pp.20-22. They used four inputs rather than two. they are capital, labor, energy and material. In their study, they reported declining capitql productivity for Japn between 1973 and 1977. Then they also reported that the contributions of energy and labor are negative for Japan, and that labor is negative for the U.S. Unlike this study, they do not assume external effects, and their regression involves factor share of the inputs.

Except for specification (S-iv) in backward-looking mode, the Chi-square-statistics indicate that the null hypothesis of constant returns to scale can be rejected. This means that the specification (S-iii) , where export is treated as endogenous, exhibits increasing returns to scale regardless of the behavioral assumptions. For the model in which exports are exogenous, the underlying production functions may exhibit constant returns to scale.

V. Conclusion

In this paper data from Japan were used to evaluate the existence of external effects and increasing returns to scale in the aggregate production function. External effects are assumed to be generated by exports. Kennan model of partial adjustment and the estimation methods (1979) is employed to obtain deep parameters of the Japan's aggregate production function.

Two different assumptions about the outlook of the economic agent are examined. First, the agent is assumed to be backward-looking. Then, the agent is assumed to be forward-looking. These behavioral assumptions have implications for the stability of the system. The forward-looking assumption clearly indicate that the system is stable, while the backward-looking assumption leaves ambiguity about the stability of the system.

The computed parameters of the production function indicate that labor is more important input than capital because (1) the elasticity of labor input is greater in absolute value, and (2) The external effects of exports are likely to be transmitted through labor.

One of the most puzzling results is the negativity of the capital coefficients and persistent negativity of effect of exports on the capital equation. The negative elasticity of capital means that the contribution of the capital input to the growth rate is negative. Two possible explanations are the following: (1) Because the agents are very optimistic about the future and the unit cost of labor is increasing rapidly, the over-substitute capital for labor. Therefore, increased levels of capital input may lead to the range of diminishing returns, (2) There may be a structural break-down during the estimated period, so that the estimates, based upon the assumption of a single trend, may bias the effects of inputs upward.

Finally, the estimated returns to scale, under the specification of exclusion of external effects is greater than those with external effects, indicating that the inclusion f exports is necessary to obtain reasonable figures for the returns to scale.

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