THE GROWTH PATH OF FIRMS AND THE DEVELOPMENT PROCESS OF THE ECONOMY: THE CASE OF JAPAN

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I. INTRODUCTION

INDUSTRIALIZATION, or the development of manufacturing firms, is only one aspect of economic development, but an important one. The reason being that in many economies the manufacturing sector generates income far above that produced by most of the rest of the economy.

In this paper I will explain the mechanism of the development process of the economy by analyzing the microeconomics of the growth process of manufacturing firms. The economy grows when its firms grow rapidly and stagnates when the firms phase into maturity after rapid growth. I will explain the development process of the economy by showing how firms grow.

There are different scales of firms: some large and some small, each contributing in different degrees to the growth of the economy. Industrial dualism—the coexistence of large-scale firms equipped with modern technology and small-scale firms with traditional family labor—often observed in developing economies has attracted considerable attention by economists.[1] Elsewhere I have discussed the important role that Japan's industrial dualism played in her rapid postwar economic development [1].

Observing that different scales of firms exist, the assumption is made here that firms go through stages from small, to medium, and then to large scale, thus reaping economies of scale or suffering from diseconomies of scale after a certain size firm has been achieved.

In a recent article [3] Professor Diwan has presented a very illuminating interpretation of the variable-elasticity-of-substitution (VES) production function. He explained the growth path of firms using technological factors derived from estimates of the VES function. The technological factors he was concerned with are (1) elasticity of substitution, (2) technological impact on labor efficiency, and (3) bias of technological change.

The growth process of the U.S. firms in 1955, 1956, and 1957, as discussed by Diwan, is as follows.

> As the firm grows from small to medium, all these technological factors are becoming more effective. There is greater factor substitution thus allowing greater flexibility and maneuverability. The impact of technological change is to make labor more efficient so that technology is more productive. One has a hunch that there

[1] For discussion on dualism, see W. A. Lewis [6], Dale Jorgenson [5].

would be economies of scale compounded in this process. The technical change is less biased implying a stable or efficient matching of resources. Yet if the firm still grows in size, these advantages are lost. [3, pp. 41–42]

I have applied the same technique to the Japanese manufacturing firm situation of 1968. Estimated technological factors show a growth path resembling a U-shaped curve. This is an interesting contrast to the growth path derived by Diwan for U.S. firms, which showed an inverted U-shaped curve.

I believe that this contrasting feature of the Japanese manufacturing firms is due to her peculiar market structure. It may be inferred from the results that Japanese large-scale firms are still the prime mover of Japan's economy and have not entered into a phase of maturity—stagnant in technological adoption—as observed by Diwan for the U.S., and that small-scale firms, on the other hand, are still very much alive and are not about to be phased out as industrialization continues. The resiliency of Japan's small-scale firms observed from the results may shed some light on the situation of Japan's oft debated industrial dualism.

II. LABOR PRODUCTIVITY

When analyzing the growth process of firms or economies, one of the most often used criteria is output (value-added) per man—labor productivity. Output per man of a firm grows when labor input becomes more efficient. This can happen when the firm is equipped with more capital. With more capital and/or more labor, increasing returns to scale may come in thus enhancing still further output per man.

I have also observed that with a given change in factor prices some firms are quick to adopt to this change by substituting relatively cheap inputs for relatively expensive ones, while other firms are slow to adapt to this changed situation. This is due first to organizational factors and second to the elasticities of substitution of inputs of different firms. Some firms are keenly observant of changing factor prices in order to reduce their production costs. Technology of some firms may warrant the case of factor substitution, while technology of other firms may not.

We can say, therefore, that over the long run, output per man grows as a result of one or a combination of the following forces: (1) a large endowment of capital per worker, (2) increasing returns to scale: an increase in the elasticity of substitution or technological progress which might be embodied in the factor inputs or which might also be disembodied or organizational, (3) a form of technological progress which does not require association with new investment in order to take place.

III. ESTIMATION EQUATION

Among studies on labor productivity the ones which have attempted to explain labor productivity in the following ways are of main concern:

$$\log \frac{V}{L} = b_0 + b_1 \log W , \tag{1}$$

$$\log \frac{V}{L} = b_0 + b_1 \log W + b_2 \log \frac{K}{L} , \tag{2}$$

where V is value-added, L labor input, K capital input, and W the wage rate.

The first is the celebrated, but somewhat censored, SMAC formulation, from which the constant-elasticity-of-substitution (CES) production function was derived [2]. b_1 is the estimated elasticity of substitution between capital and labor.

SMAC has tried to explain differences in labor productivity in manufacturing industries across countries. For our purpose the pertinent question they present can be posed as follows: How much of the observed difference in labor productivity can be explained by the difference in the capital-labor ratio? But the data of capital-labor ratio are hard to obtain. So the wage rate is used, since the wage rate is a function of the capital-labor ratio.

As SMAC has shown, the least squares estimate of the equation (1) has remarkably good fit and in most cases b_1's turned out to be less than unity.

Since many studies have commented on various aspects of the SMAC formulation and explored its serious difficulties, there is no necessity for detailed discussions here. I will concur here with Lu and Fletcher who point out that the weakest point of the SMAC formulation is the assumption of ". . . the existence of a relationship between V/L and W, independently of the stock of capital" [7, p. 449].

Then if data on stock of capital is available, one of the plausible things to do would be to regress V/L on W and K/L as in the equation (2). This is exactly the way Hildebrand and Liu estimated their production function [4].

Hildebrand and Liu suggest:

> If one relies upon the goodness of fit of empirical relationship as the initial basis for deriving a theoretical one, one probably would have to consider the three-variable relationship (V/L, W, and K/L) as better established than the two-variable one (V/L and W). [4, p. 35]

Recently Nerlove [8] has shown that from (2) the variable-elasticity-of-substitution (VES) production could be obtained.

The VES production function can be written as

$$V^{-\rho} = (A_1 K)^{-\rho} + (A_2 L)^{-\rho} \frac{K}{L}^{-m\rho} , \tag{3}$$

where A_1 and A_2 measure capital and labor in efficient units, respectively. m and ρ are parameters.

The elasticity of substitution of the VES is:

$$\sigma_b = \frac{1}{1 + \rho - (m\rho/S_K)} , \tag{4}$$

where S_K is the share of capital.

In contrast the CES production can be written:

$$V^{-\rho} = (A_1K)^{-\rho} + (A_2L)^{-\rho} \tag{5}$$

and the elasticity of substitution is:

$$\sigma_n = \frac{1}{1+\rho}. \tag{6}$$

Diwan has presented a very insightful interpretation of m and of the VES function. He hypothesizes that labor input measured in efficient units is a function of the capital-labor ratio (d refers to the operator dt):

$$\frac{dA_2}{A_2} = m\frac{d(K/L)}{K/L}, \tag{7}$$

or

$$A_2 = A_2\left(\frac{K}{L}\right)^m. \tag{8}$$

That is, as Diwan states,

> It will therefore seem that labor productivity is a function both of capital intensity and education, research and development expenditure. However, education, research and development will effect the technical knowledge which is brought about by new investment which in turn changes the capital intensity. The capital intensity will seem to be used in a first approximation approach. [3, p. 31]

Substituting (8) into the CES function (5), we obtain the VES function (3).

From estimates of b_0, b_1, and b_2, the following technological factors can be derived in addition to σ_b which is defined already in (4)

$$m = \frac{b_2}{1-b_1}, \tag{9}$$

$$g = 1 + \frac{m\rho(S_K - {}^rS_L)}{m\rho S_L - (\rho+1)S_K}, \tag{10}$$

where S_L refers to the share of labor. g is a measure of the biasedness of technological change, such that $g \gtreqless 1$ implies labor using (capital saving), neutral and labor saving (capital using) technical change, respectively. m is a measure of the impact of technology on the efficiency of labor.

IV. ESTIMATION RESULTS

Diwan applied (2) to the U.S. manufacturing firms for 1955, 1956, and 1957. He calculated m, g, and σ's from estimated b_0, b_1, and b_2. His conclusion was,

> All three technological factors describe an inverted U-shaped curve in the technological factor and output (or firm size) space—the latter being the X-axis. In other words, these technological factors, contrary to the average cost, grow with the firm, reach a maximum and start falling off. [3, p. 30]

I have applied (2) to the Japanese manufacturing firms of 1968. Firm sizes are determined by the number of employees. Estimates are presented in Table I. The technological factors are calculated from the estimates of b_0, b_1, and b_2. They are presented in Table II.

Fig. 1.

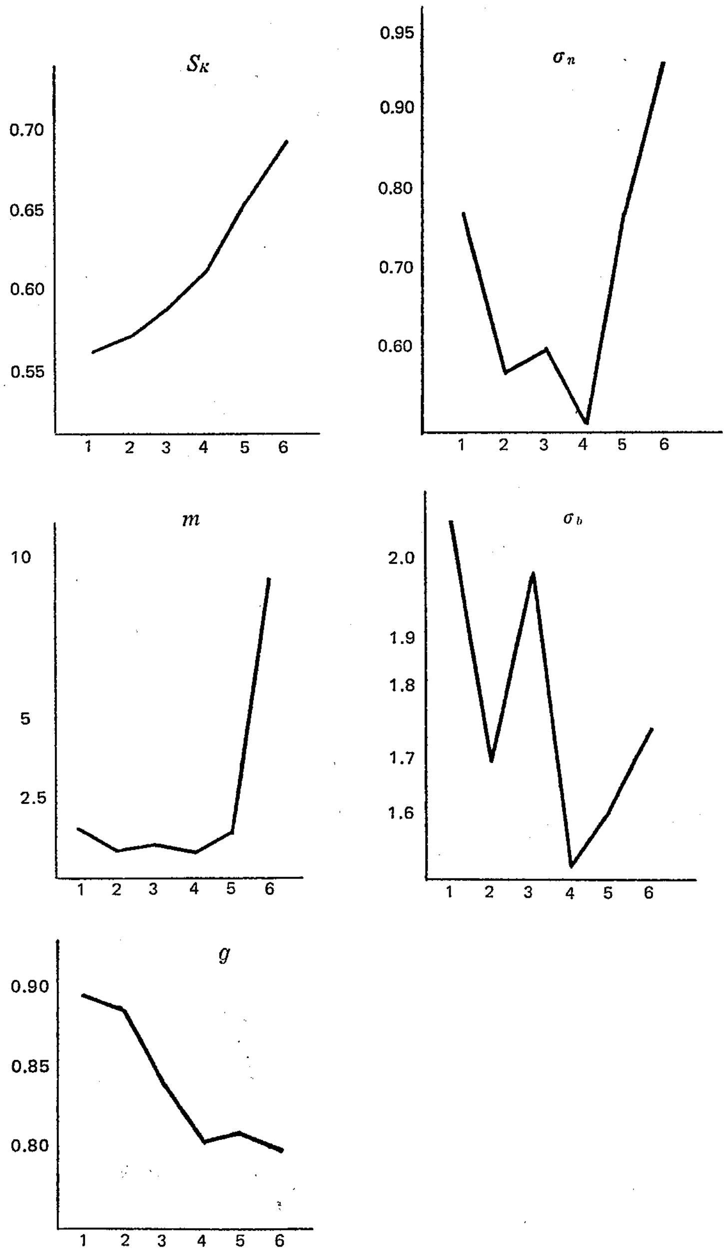


TABLE I

$$\log(V/L) = b_0 + b_1 \log W + b_2 \log(K/L)$$

Firm Size	b_0	b_1	b_2	R_2
10– 19	.0570	.7699 (5.8661)	.3529 (5.1460)	.8672
20– 29	1.0896	.5736 (4.5363)	.3761 (7.2992)	.8999
30– 49	.7150	.6012 (5.7337)	.4064 (9.7112)	.9513
50– 99	1.3048	.5115 (3.9414)	.4034 (9.5755)	.9458
100–299	.1065	.7775 (4.4831)	.3369 (5.3083)	.9004
300 over	−.9576	.9670 (3.6267)	.3138 (4.6925)	.8730

Source: Japan Ministry of International Trade and Industry, *Kōgyō tōkei-hyō* [Census of manufactures], 1968.
Note: Numbers in parentheses are *t*-statistics.

TABLE II

CAPITAL'S SHARE IN VALUE-ADDED, LABOR EFFICIENCY PARAMETER, BIASEDNESS OF INNOVATION AND ELASTICITIES

Firm Size	S_K	m	g	σ_n	σ_b
10– 19	.5589	1.5341	.8975	.7699	2.0921
20– 29	.5689	.8820	.8869	.5736	1.6926
30– 49	.5833	1.0191	.8365	.6012	1.9826
50– 99	.6096	.8258	.8044	.5115	1.5119
100–299	.6510	1.5142	.8092	.7775	1.6113
300 over	.6892	9.5091	.7995	.9670	1.7743

These calculated values of the technological factors are plotted in Figure 1. As can be seen, m and σ's are close to U-shaped. This is an interesting contrast to the inverted U-shaped curves found by Diwan for U.S. manufacturing firms.

V. EXPLANATION AND CONCLUDING REMARKS

In order to explain the rather peculiar shaped curves of the technological factors of Japanese firms, summary statistics on the structure of the Japanese manufacturing firms of 1968 are presented in Table III. Some are plotted in Figure 2.

As can be seen from Figure 1, the calculated values of σ's, m, and g are relatively large for the small-scale firms of ten to nineteen employees. In view of the fact that in 1968 Japan was already the world's third largest industrial nation, large numbers for small-scale firms may be surprising. This, I believe, indicates the resiliency of Japanese small-scale firms. These firms are very much alive and not about to be phased out as industrialization progresses.

Though small in size, these firms are in many cases closely tied to large-scale firms in the form of the subcontracting system, receiving second-hand machinery from parent firms and in return supplying them with parts for products.

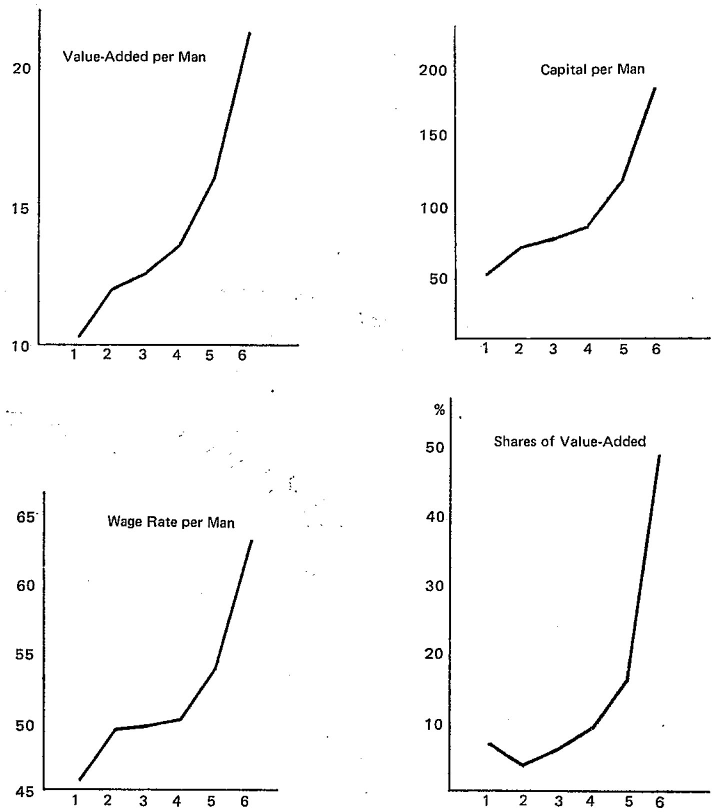
TABLE III

INTERSCALE DIFFERENTIALS IN JAPANESE MANUFACTURING INDUSTRIES, 1968

Size of Firm (No. of Workers)	No. of Establish-ments (%)	Output (%)	Value Added (%)	Wages per Man (1,000 Yen)	Value-Added per Man (1,000 Yen)	Capital per Man (1,000 Yen)
4– 9	56.2	4.8	6.3	404	776	—
10– 19	22.2	6.5	7.5	455	1,035	535
20– 29	6.9	4.3	4.5	499	1,214	733
30– 49	6.1	6.3	6.4	500	1,261	790
50– 99	4.7	9.9	9.7	505	1,364	872
100–299	2.9	17.4	16.8	540	1,604	1,209
300 over	1.0	50.8	48.8	638	2,122	1,850
Total (average)	100.0%	100.0%	100.0%	438	957	310

Source: Calculated from Japan, Ministry of International Trade and Industry, *Kōgyō tōkei-hyō* [Census of manufactures], 1968.

Fig. 2.



Large estimated parameters for large-scale firms are expected as they have been the prime mover of the Japanese economy. Unlike their U.S. counterpart, they have not entered a phase of maturity.

Some difficulties may be encountered in explaining the small parameters of medium-size firms. One plausible explanation would be this: for these firms strong labor unions have been established, hence the rate of increase in wage rate has been slow. They have not, therefore, faced an acute need to introduce more capital-intensive techniques. This will be indicated by the relatively small m's estimated for these firms.

The small-scale firms, on the other hand, though they do not have any unionization to speak of, have been exposed to the labor squeeze when more workers were absorbed by large-scale firms by the quickening pace of growth of Japan's postwar economy. These small-scale firms have counteracted the rising tendency of the wage rate by successfully introducing second-hand machinery. This is a reason that these firms have high σ's.

In sum, the VES production function provides very illuminating information on technological factors of the firms and their growth process.

Though crude, the results show that the Japanese small-scale firms, like their large-scale counterparts, are technological innovators in their own right. The resiliency of Japanese small-scale firms shown in these results will, I believe, shed some light on the situation of Japan's industrial dualism.

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