Production Costs and the Speed of Response to Investment Stimulants

C. Tait Ratcliffe

I. Introduction

In reviewing the literature on the subject of production costs over time, and the other side of same coin, the subject of returns to scale, it is difficult to escape the conviction that attention has been focused on the aggregate level for too long. Given the the difficulties of measuring the quality of factor inputs into an aggregate production function, it would appear that someone would have attempted a more detailed study of returns to scale on a more disaggregated basis, preferably avoiding the problem of measuring labor and capital in homogeneous, efficiency units altogether. Attempts in this direction, except for those summarized below have been few and far between. Instead attention has been focused upon solving the problem of correctly meassuring both capital and labor inputs by means of more accurate index number approaches.[1] The conclusion which stood for some time was that of Solow, that the usual measures of inputs of capital and labor in the aggregate production process left much of the increase in output unexplained.[2] The residual was ascribed to technical progress or to improvement in the quality of the factor inputs, either embodied or disembodied technical progress. This increase in quality led to more output for the same real dollar expenditure on input.

Jorgenson and Griliches succeeded in reducing this residual by taking account of the increasing rate of utilization of equipment, and improvement in the quality of factor inputs.[3] More recent work by Christenson and Jorgenson indicates that the original

conclusion of Jorgenson and Griliches must be revised.[4] Prod--
uctivity growth is not in fact negligible as originally believed,
although increases in real factor inputs ("real" in the sense that all
changes in quality has been accounted for and inputs are hom-
ogeneous with respect to productive efficiency) account for most
increases in production.

Rather than attempt to contribute to this subject, it appears
useful to raise a few questions instead.

1. Would not a more disaggregated approach to the problem
   of productivity be more useful, especially in providing
   empirical guidance for further theoretical studies on the
   behavior of firms?

2. Has not the definition of productivity changed from the
   heyday of the "residual" to the examination of "real" inputs?

To consider the second question first. By including changes in
quality in the index of inputs into the aggregate production
process, recent authors have undoubtedly made a significant
contrbution.   But it is difficult to escape the conviction that
theirs is a good answer without a question.

They have in fact redefined the problem. Whereas productivity
as a "residual" was something mysterious, the sources of incre-
ases in productivity can now be assigned to certain factors of
production, with varying degrees of accuracy of course. But
these are still highly aggregated inputs. What has caused the
change in the quality of these inputs? Simply because the
residual becomes smaller and smaller, is this clear evidence that
the factors chosen for accounting for productivity change are
in fact the correct ones? This is after all a difficult subject to
verify directly. If the attempt to convert inputs into the prod-
uction process into units that are homogeneous technologically
is successful, is this anything more than a rearrangement of
the problem of what causes an economy to get more than its
money's worth for expenditure on factor inputs?

Even if all increases in output could be assigned ultimately to some past expenditure in the aggregate, is information on aggregates of relevance in the following;

(a) The study of firm behavior and its implications for future characteristics of production processes by firm, product line, industry or in the aggregate.

(b) Planning for the individual firm, which may have a wide range of items it could potentially produce.

(c) In planning by the state for guidance in industrial development.

As for the first question, we might ask what we are trying to find out from investigations of productivity. An approach which might be equally as useful would be:

(1) To ask what has been the behavior of production costs over time, in detail by product.

(2) To ask, if there is clear evidence of decreasing costs, what are the causes of this?

A serious review of these two questions could lead to a number of prescriptions for setting firm and government policy and for advancing the study of firm behavior.

In the following pages we shall summarize first a series of findings on the behavior of cost on a by-product basis. The striking feature of these results is the prevalence of declining costs with increases in total production accumulated over time. While increases in scale may account for much of this decline in cost, one might observe that cost appears to decline predictably as cumulative experience in production increases. This finding has clear implications for firm behavior and hence for many branches of economics. Given these results, we go on to present a discussion of the relationship between these findings and other results obtained in measuring the response of industries to investment stimuli. Given these two sets of results, the first of which states that for a significant set of products, cost

decline predictably as production increases, and the second, that not all industries approach expansion of capacity with equal speed, we draw some informal and speculative conclusions on the implications for firm behavior, on the speed of economic expansion and its effects on cost, and on implications for international trade.

## II. Recent Findings in the Study of Production Costs

Courses in elementary economics begin by stating that firms have a short run horizon and a longer run horizon. In the short run, marginal costs rise as the quantity of production is increased. In the long run, i. e. long enough to increase capacity, the firm's costs may go up or down depending upon the nature of the production process. The student is given to understand that returns to scale may be decreasing, constant or increasing and therefore is left an agnostic so far as the subject is concerned. Subsequent study generally involves the assumption time and again of constant returns to scale, because of the mathematical simplicity of models based on constant returns.

Numerous articles in economics begin by stating how surprising it is that some piece of research has not yet been undertaken, then proceed to present research on that subject. In the light of recent findings it is indeed surprising that economists should have neglected to look at the behavior of costs on a product basis. The results have clear implications both for economic theory and economic behavior.

The results summarized below have been prepared by the Boston Consulting Group in connection with a research project on the behavior of industry and firm costs.[5] Their approach has been to plot average unit costs of products against a number of other variables. A high degree of regularity was observed for many products when the unit cost was plotted against the accumulated volume. To give a specific example from the elec-

tronics industry :

GERMANIUM TRANSISTORS

Industry Total Accumulated Volume
(Million units)
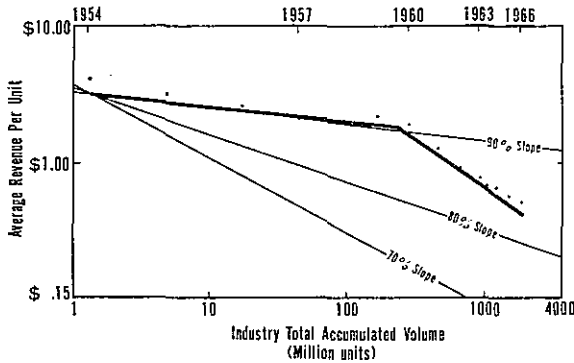
YEAR	INDUSTRY TOTAL ACCUMULATED VOLUME (MILLION UNITS)	AVERAGE REVENUE PER UNIT ($ CONSTANT)
1954	1.3	$3.56
1955	4.9	2.88
1956	17.3	2.34
1957	45.0	1.85
1958	90.0	1.79
1959	167.5	1.96
1960	286.6	1.70
1961	464.5	1.14
1962	678.2	0.82
1963	927.6	0.69
1964	1,216.4	0.57
1965	1,550.0	0.50
1966	1,900.0	0.45

Source: Derived from published data of Electronics Industry Association
Boston Consulting Group estimates

There are number of points which require clarification and one of them is the conversion to constant dollars. The usual method of converting current prices to constant in economics is to divide by a price index for that particular product. Since the measure of cost in this case is an indirect one, output price, division by an index of output price would yield a constant value for price. This would clearly reduce the information content of the price series to zero. What is relevant of course is not the

"constant" price series but the price of a good relative to the prices of other goods, and the level of income. If income and all other prices are constant, except for the price of the item being considered, then this item is becoming relatively less expensive. If this item happens to be an input, under the usual economic theory of the firm, cost-minimizing firms will shift to use of this item if substitution possibilities exist, due to changes in the relative prices of inputs. The actual money cost of the item is therefore the relevant measure of the cost in this particular case.

If income should be constant and prices of other goods are rising, then the actual money cost will be an over-estimate of the cost. The appropriate deflators would be as follows:

1. For a consumer good, the price should be divided by the weighted average price index for consumption goods, for that consuming agent.
2. For a capital good, it should be deflated by the capital goods price index, for that investing agent.
3. For intermediate goods or factor inputs, these should be divided by a price index for all the intermediate goods or factor inputs used by that producing agent.

As an approximation to all of these the Boston Consulting Group has used the GNP deflator. This has clear limitations since the prices of capital goods in particular may be either constant or declining. Depending upon whether the rate of decline of prices of other capital goods happens to be greater or less than that of the good in question, the price of that good will become relatively more or less expensive. But the fact that the costs of inputs are declining is of course clear, so the question of relative costs becomes less important.

As the examples on the following pages indicate, the vertical axis represents the price per unit, while the horizontal axis represents the total accumulated volume. The labelling of the

MONOCHROME TELEVISION RECEIVERS
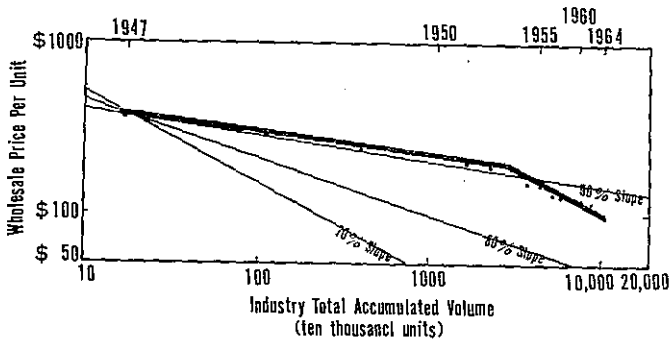
YEAR	INDUSTRY TOTAL ACCUMULATED VOLUME (10,000 UNITS)	WHOLESALE PRICE PER UNIT ($ CONSTANT)
1947	18	376
1948	116	296
1949	416	249
1950	1,162	226
1951	1,700	208
1952	2,310	197
1953	3,032	193
1954	3,767	156
1955	4,543	152
1956	5,282	135
1957	5,922	134
1958	6,414	135
1959	7,049	126
1960	7,620	127
1961	8,238	118
1962	8,885	121
1963	9,598	110
1964	10,409	100

Source: Derived from published data of Electronics Industry Association
Boston Consulting Group estimates

horizontal axis raises some questions, since it is not a method of looking at production familiar to economists. But it is clear that declining price per unit is not the result simply of the labelling of the horizontal axis. This affects only the spread of the points in the horizontal direction.
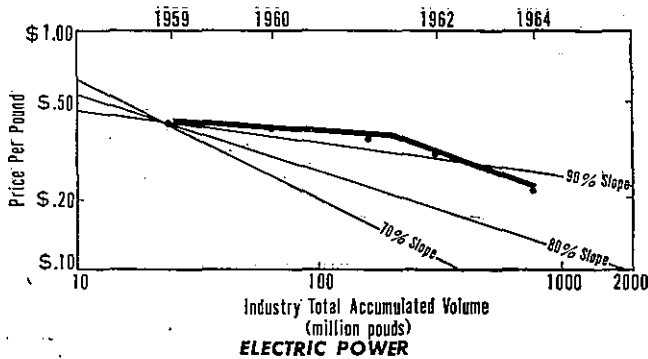
A question might be raised as to why revenue or price of the product per unit has been used rather than some concept such as value added, etc. The answer is that data on output price is

ELECTRIC POWER

Industry Total Accumulated Volume
(million kwh)
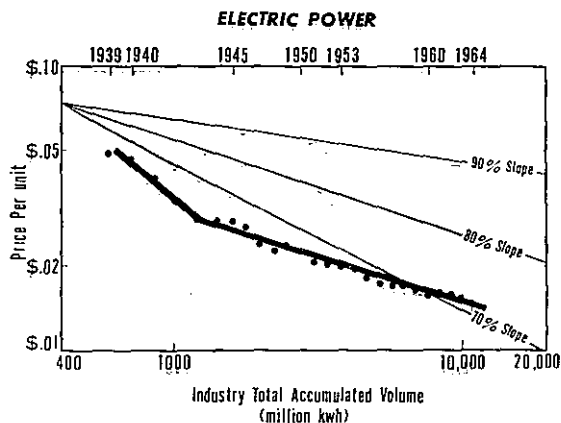
YEAR	INDUSTRY TOTAL ACCUMULATED VOLUME (BILLION KWH)	PRICE PER KWH ($ CONSTANT)
1939	600	.0499
1940	719	.0468
1941	859	.0401
1942	1,018	.0337
1943	1,204	.0290
1944	1,402	.0284
1945	1,596	.0287
1946	1,787	.0272
1947	2,005	.0237
1948	2,246	.0224
1949	2,495	.0233
1950	2,776	.0224
1951	3,094	.0205
1952	3,437	.0204
1953	3,821	.0199
1954	4,232	.0196
1955	4,713	.0183
1956	5,243	.0174
1957	5,801	.0169
1958	6,370	.0171
1959	6,997	.0165
1960	7,678	.0157
1961	8,399	.0161
1962	9,175	.0158
1963	10,006	.0153
1964	10,896	.0148

Source: Derived from published data of U.S. Department of Commerce
Boston Consulting Group estimates

more readily available than data on production costs. But the
relationship between output price and costs needs to be explored
in more detail, since it does not appear to have been raised as

POLYPROPYLENE

Industry Total Accumulated Volume
(million pouds)

ELECTRIC POWER

YEAR	INDUSTRY TOTAL ACCUMULATED VOLUME (MILLION POUNDS)	PRICE PER POUND ($ CONSTANT)
1959	25	.413
1960	66	.397
1961	163	.364
1962	308	.312
1963	505	.271
1964	778	.221

Source: Derived from published data of Manufacturing Chemists' Association
Boston Consulting Group estimates

a specific problem in economics. In fact there are only three
possibilities.

PRIMARY MAGNESIUM
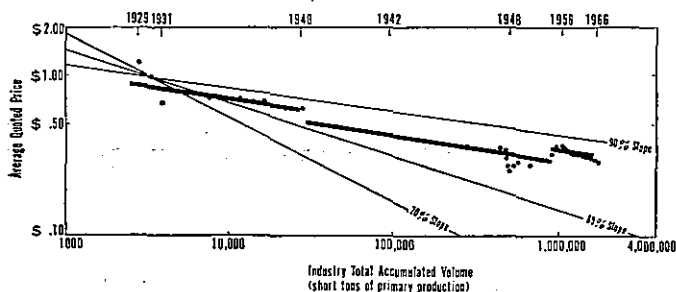


Industry Total Accumulated Volume
(short tons of primary production)

| YEAR	INDUSTRY TOTAL ACCUMULATED VOLUME (SHORT TONS OF PRIMARY PRODUCTION)	Continued AVERAGE QUOTED PRICE PER POUND ($ CONSTANT)
1929	2,760	$1.186
1930	3,347	.974
1931	3,847	.670
1932	4,347	.746
1933	5,347	.763
1934	7,347	.711
1935	9,347	.704
1936	11,347	.702
1937	13,617	.674
1938	16,027	.683
1939	21,352	.625
1940	27,613	.615
1941	43,908	.477
1942	92,871	.424
1943	276,455	.361
1944	433,555	.352
1945	466,347	.343
1946	471,664	.307
1947	484,008	.275
1948	494,011	.258
1949	505,609	.259
1950	521,335	.274
1951	562,216	.286
1952	668,037	.280
1953	761,112	.301
1954	830,841	.301
1955	891,976	.324
1956	960,322	.361
1957	1,041,585	.362
1958	1,071,681	.352
1959	1,102,714	.347
1960	1,142,784	.341
1961	1,183,529	.337
1962	1,252,484	.333
1963	1,328,329	.329
1964	1,407,817	.323
1965	1,489,178	.318
1966	1,568,972	.309

Source: U.S. Bureau of Mines

(a) Price declines more rapidly than cost, leading eventually
to an intersection of the price line and cost line:
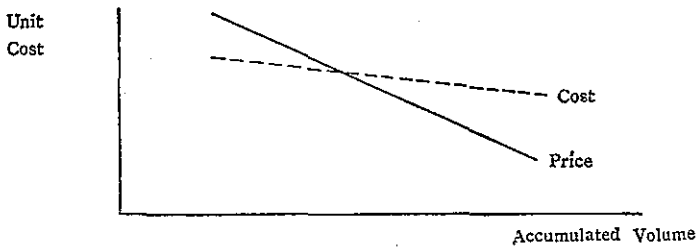
(b) Price declines in parallel with cost. Non-parallel move-
ment would lead to either (a) or (c) below.
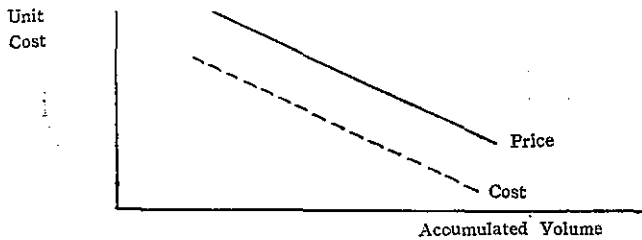
(c) Price declines at a lower rate than costs, with profits
per unit increasing.
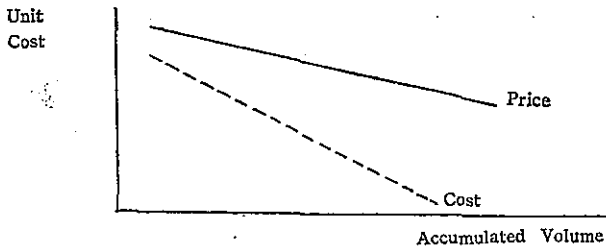
In short price must decline, if it declines at all, at a slower,
faster or at the same rate as costs. Case (c) would represent con
stant or increasing price with declining costs. But this is not
relevant since the quetsion is : Does declining price mean declining
cost ? It is clear that except in case (a), which can exist only tem-

porarily, declining price will indicate declining cost. Of course this does not rule out completely the possibility of costs declining with rising or constant price, temporarily. One exception to this would be the case where free entry allowed more and more competitors into a market, shifting the supply schedule and gradually reducing the level of price and profit for all firms. In fact in all cases of declining costs examined, the reverse was the case. The number of firms generally was small and decreasing, rather than large and increasing.

In examining various possibilities for the labelling of the horizontal axis, a high degree of regularity was found when accumulated production volume was used and both scales were plotted a log scale. The slope of the declining cost curves show a fairly high degree of regularity. The 90 percent slope, 80 percent slope, etc. indicate that for declining cost curves with a slope of 90 percent, costs decline to 90 percent of their former level each time the accumulated production volume doubles. The greatest cost savings for the products examined here would appear to be near the beginning of their product life. It naturally becomes more and more difficult to double the size of accumulated volume if demand approachs a saturation level.

The conclusions which can drawn from this empirical investigation may be briefly summarized as follows:

(1) Costs appear to go down on value added at about 20 to 30 percent every time total production experience doubles for the industry as a whole as well as for individual producers.

(2) If cost is a function of accumulated production, then market share has a calculable value. The faster a firm expands its accumulated volume in relation to other firms, the faster its costs will decline relative to other firms and the better its competitive position.

(3) Given a steady and predictable increase in demand, the firm with the fastest response to investment simuli will have

the lowest costs, provided the response speed is consistent and capacity is fully utilized.

(4) With cost decline predictable, the firm can set its price at a sufficiently low level to discourage entry of competitors, yet still expect a higher return later as costs decline.

The limitations of this analysis are :

(1) The authors have not analyzed in detail the causes of the decline in cost. This detracts from the reliability of using this method to forecast cost behavior.

(2) The authors have failed to point out where this phenome non is not likely to occur. It therefore becomes difficult to. attempt generalization to a more aggregate level.

Note however that generalization to a more aggregate level is not necessary for several very important economic decisions :

(a) The firm's decisions on pricing, expansion and choice of future product areas.

(b) The economic planner's choice of guidelines for pricing, provision of funds for expansion, allocation of funds for new product development, and content of the guidance provided to industry. With cost declining, the speed of expansion of output becomes a critical issue in remaining competitive in domestic and world markets. The issue of aggregate productivity need not be raised. Thus indeed from the point of view of corporate strategy planning and many decisions in economic planning, answers to the question of aggregate productivity are answers without questions.

While the implications of these findings are numerous, we shall not dwell on them at this point, but instead go on to consider the relationship of this set of findings to a theory of investment behavior and to findings concerning the speed of investment response.

III. A Theory of Investment Behavior

Ideally investment is a response to a careful and accurate appraisal of future demand. Ideally, the increments to capacity are brought to full utilization according to plan and the firm supplies itself with the right flow of capital services to optimize its objective function, whatever that may be. At worst investment is a response to an already existing excess of demand over supply, that is, investment in the present period is the result of changes in the optimal level of capital, derived from a set of assumptions about the behavior of firm, in the past. Which of these modes of behavior is in fact brought to realization by firms is not a question for theoretical discussion. Either could be the mode of behavior. The problem is to define the value of optimal capital stock and the changes in this variable for each case and test the relationship between the change and the actual level of investment.

In both, the best and worst, net investment will be a weighted average of these past changes in optimal capital services. When the value of investment for replacement is added, the total will equal gross investment. In the following pages we present several results obtained in testing a distributed lag investment function using data for U. S. and Japan. The economic theory behind this investment function and the method of measuring lags were brought together originally by D. W. Jorgenson about ten years ago.[6] The results for the U. S. were prepared by Jorgenson and Stephenson and the results for Japan were prepared by the author.[7]

To summarize the theory of investment behavior which is common to both sets of results: Investment is assumed to be composed of two elements, net investment or additions to existing capacity and replacement. Net investment is hypothesized to be a distributed lag function of past changes in the

level of optimal capital stock, derived from the assumption that firms chose their inputs to maximize the residual left after factors of production have been paid from gross revenues. The residual is then left for future investment. The assumption behind this theory of investment behavior amounts to the assertion that firm maximize their net investment for growth when choosing the proper level of inputs. The level of replacement is hypothesized to differ from the accounting value of depreciation and to be close to a constant fraction of capital stock measured in constant value terms.

The objective function of the firm is written :

$$pQ - \sum_i c_i X_i, \text{ or}$$

[Revenue] − [Expenditure on Inputs]

and the function is maximized subject to a temporarily constant level of technology :

$$\Psi = pQ - \sum_i c_i X_i + \lambda \ (Q - Q \ (Xi))$$

The implication of this optimization is that :

$$\frac{\partial Q}{\partial X_i} = \frac{Ci}{p}$$

For a specific form of the production function :

$$Q = \overset{m}{\underset{j}{\Pi}} \ X^{\alpha_j}$$

This same derivative equals :

$$\frac{\partial Q}{\partial X_j} = \alpha_j \frac{Q}{X_j}$$

Thus solving for the optimal level of capital stock ; Xj :

$$X_j^* = \alpha_j \frac{pQ}{c_j}$$

This is the level of capital stock which will enable the firm to have the largest residual after payments for the factors of production. For the firm maximizing its market share by expanding at the greatest possible rate this will be the approp-

riate level of capital stock, just as it will be the appopriate level for the firm maximizing its profit. The change in this level of capital stock will be equal to the appropriate level of investment.

Since investment cannot be completed instantaneously, but must go through a process of planning, letting of contracts, construction, etc. the level of net investment is hypothesized to be a distributed lag function of past changes in the level of optimal capital stock.

$$NI_t = \mu_1 \Delta X^k_{jt-1} + \mu_2 \Delta X^*_{jt-2} + \cdots + \mu_n{}^*_{jt-s}$$

Replacement investment, as a constant function of the level of capital stock in the previous period is added to arrive at the complete specification:

$$RI_t = \delta K_{t-1}$$

$$GI_t = \sum_{s=o}^{n} \mu_s \Delta \chi^*_{jt-s} + \delta K_{t-1}$$

In actual estimate, to reduce the number of parameters to be estimated, the following specification is employed.[8]

$$GI_t = \sum_{s=o}^{n} \gamma_s \Delta X^{\alpha}_{jt-s} - \sum_{s=o}^{n} \omega_2 NI_{t-s-1} + \delta K_{t-1}$$

The value of c, which may be described as the shadow price of capital services, is derived from the following definitional equation for the value of the investment good price index:

$$q^{(t)} = \int_t^{\infty} e^{-r(s-t)}[(1-u)c(s)e^{-j(s-t)} + uq(t)O(s)]ds$$

By differentiation and solution for c, we obtain:

$$c_t = q_t(\gamma_t + \delta)\frac{(1-u_t z_t)}{(1-u_t)}$$

The above investment specification has been applied to data for the U. S. and for Japan. A comparison of these results is given in the following section.

IV Empirical Findings in the Theory of Investment Behavior

The investment function described above has been applied to data for the U. S. and Japan. The results for the U. S. have already been published by Jorgenson and Stephenson. Estimates of the investment function has been made for the following industries in Japan.

Total Manufacturing
Foodstuffs
Textiles
Pulp and Paper Products
Chemicals
Ferrous Metals
Non Ferrous Metals
Metal Products
Machinery (Excluding electrical)
Electrical Machinery
Transportation Equipment
Other Manufacturing
Services

A comparison of the results for Japan and for the U. S. are given in the following table, where the industries are comparable:

	Japan		United States	
	R^2	d	R^2	d
All Manufacturing	.9700	2.09	.9644	1.96
Foodstuffs	.9397	1.98	.8108	1.99
Textiles	.6823	1.94	.8602	1.89
Pulp and Paper Products	.7458	2.00	.9461	2.19
Chemicals	.9185	1.93	.8930	1.96
Ferrous Metals	.8174	2.24	.8546	2.22
Non-Ferrous Metals	.5958	2.09	.9263	2.27
Metal Products	.8341	2.03	**	**
Machinery	.9364	1.99	.9197	2.05

	Japan		*United States*	
	R^2	d	R^2	d
Electrical Machinery	.9479	1.97	.9138	1.96
Transportation Equip,	.9598	1.88	.9197	2.05
Other Manufacturing	.9291	1.98	**	**
Services	.9038	1.61	**	**

(No comparable category for the U.S. results)
(Results for the United States are taken from Jorgenson-Stephenson, "Investment Behavior in U. S. Manufacturing, 1947—1960" Econometrica, April, 1967)
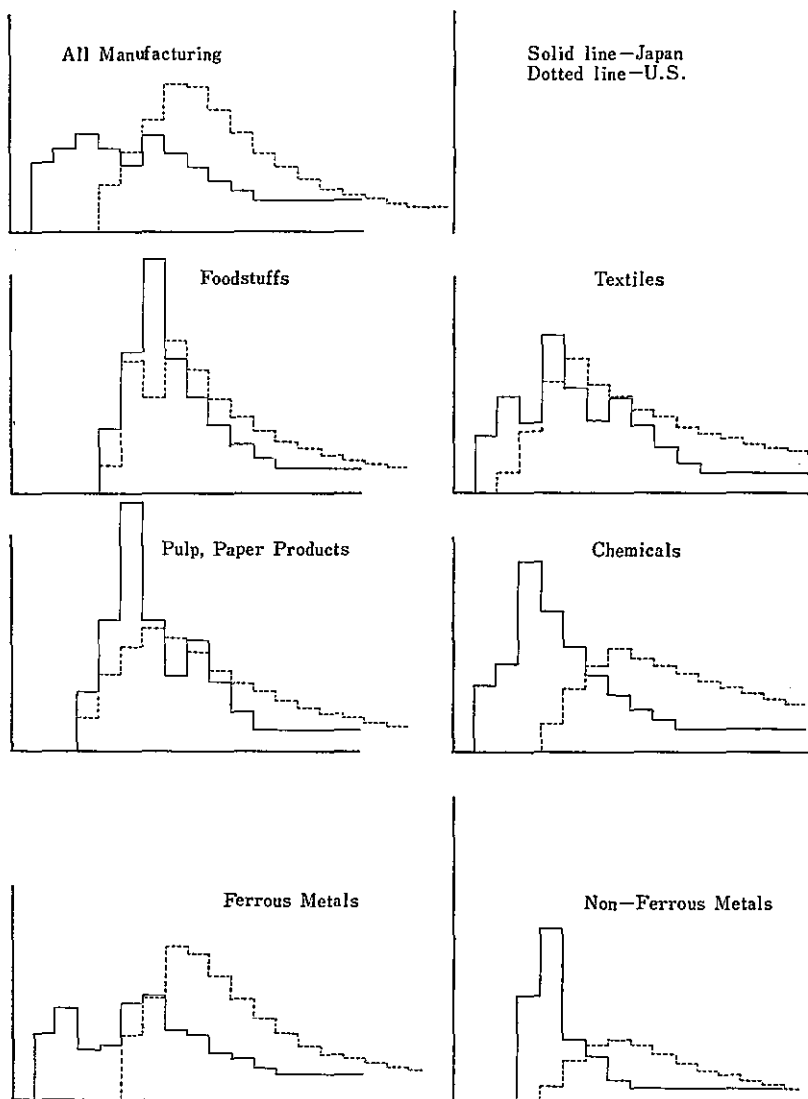
The results obtained for Japan appear to be about as satisfactory on average as those for the U. S. Results for Japan are better for six industries and not as good for the remaining four comparable categories. The poorest result of the group is that for Non-Ferrous Metals, nonetheless the F-value for this regression is almost four timesthe one percent critical value. The necessary sign conditions and conditions on the values of parameters are satisfied without resort to constrained regression. The lower R^2's in Textiles, Pulp and Paper, Ferrous Metals and Non-Ferrous Metals appear to be due in large part to the presense of severe disturbances in the investment series, even after seasonal adjustment. Desisions on the level of investment appear to have been made without as much regard for changes in the optimal level of capital stock as we would have expected. The Pulp and Paper industry in paticular ws known for periods of excess investment, followed by periods of underutilization of capacity. Considering the smooth increase in such items as liner and medium, printing paper, and newsprint, this behavior is surprising.
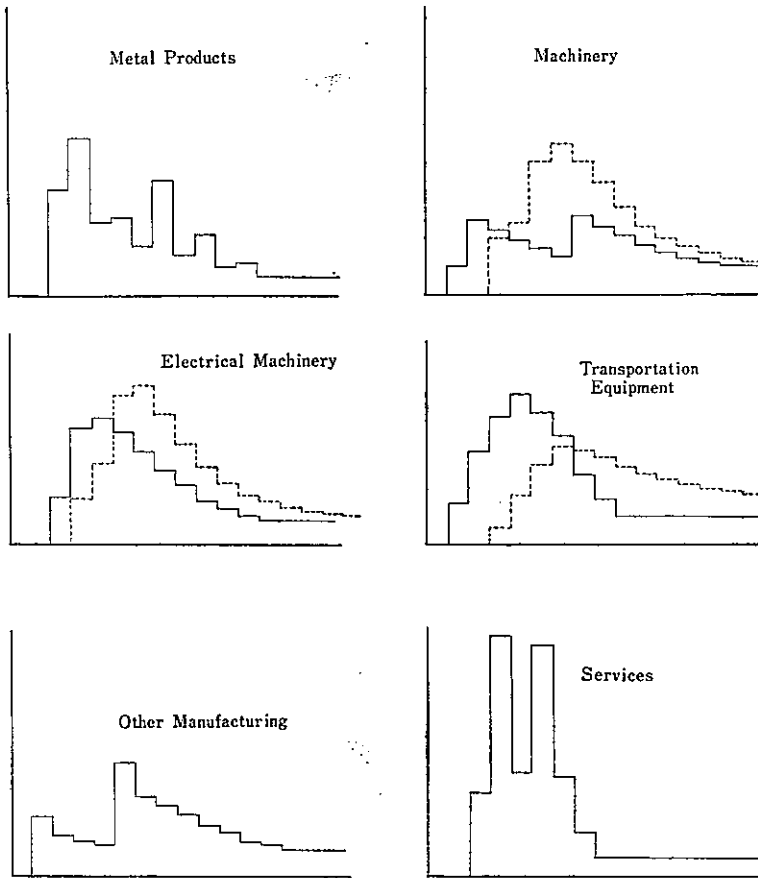
The significance of the coefficients associated with lagged optimal capital stock and net investment indicates that the theory of net investment as a distributed lag function of past changes in optimal capital stock is a valid account of the determination of net investment in most Japanese manufacturing industries. In contrast to the U. S. results, the significance of

the coefficients of optimal capital stock shows greater varaiability across industries.

The coefficient of capital stock lagged one period corresponds to the rate of replacement. Without exception this coefficient is highly significant in each regression. If the rate of replacement were not a constant or did not tend to a constant there would be not reason for the coefficient of lagged capital stock to differ from zero. We conclude that these results provide strong evidence for using a constant rate of replacement in the calculation of capital stock, rather than the variable rate of replacement which has been employed in estimates of capital stock in Japan. The rate of replacement has also been estimated using two capital stock benchmarks and the gross investment series. The independent estimates differ significantly from the regression estimates, at the five percent level in only one of the thirteen cases. The upward bias in benchmark estimates may be due to error in the prices indexes employed to deflate the capital stock benchmarks.

The lag patterns calculated from the regressions are presented on the following pages. The patterns fall into approximately three categories: These with a peak at the beginning followed by gradual decay in response. Those with a peak about five to seven quarters from the change in the optimal level of capital stock. Those with two or more peaks. A comparison of the response patterns of Japanese and U. S. manufacturing industries indicates a greater incidence of multiple peak lag patterns, and a faster approach to peak response in most industries. These results do not confirm the commonly held view that changes in the determinants of investment take effect within one or two quarters in every industry. However this view is confirmed for the aggregate category, Total Manufacturing, and for eight sub-industries of manufacturing. The response pattern of aggregate manufacturing indicates a very rapid approach to a peak,

All Manufacturing

Solid line—Japan
Dotted line—U.S.

Foodstuffs

Textiles

Pulp, Paper Products

Chemicals

Ferrous Metals

Non—Ferrous Metals

Metal Products

Machinery

Electrical Machinery

Transportation
Equipment

Other Manufacturing

Services

as opposed to the more gradual approach which is found in the
United States. The lag pattern for manufacturing as a whole
indicates changes in the determinants of investment behavior
have significant effects with one quarter. The response pattern
remains near peak level with some oscillations for seven quarters,
then decays. The effect of changes in the determinants of
investment behavior is to stimulate demand within a very short
period, to maintain approximately the same level of demand

for seven to eight quarters, then to depress demand after eight
quarters. There appears to be a danger inherent in the oscilatory
pattern of response exhibited by aggregate manufacturing, which
is worthy of note. The temporary slump in sixth quarter after
a change in investment determinants may be interpreted as a
downward trend in investment demand. Any measures taken in
the sixth quarter to stimulate demand for investment would
take effect simultaneously with the peak in the seventh quarter,
producing an unexpected burst of demand which could easily
contribute to inflationary pressures.

The following table gives the average lag to completion of
investment projects, calculated from the regressions for Japan
and the United States, as well as the Economic Planning Agency
survey estimates, made in 1959.

A comparison of average lags in U. S. and Japanese manufac-
turing industries indicates most Japanese industries bring in-
vestment to completion at a significantly faster pace, most
notably in the case of Transportation Equipment (including
automobiles).

Average Lag to Completion in Quarters

	Pascal Function		EPA Survey
	Japan	U. S. A.	
All Manufacturing	7.50	8.50	8.33
Foodstuffs	8.57	8.74	4.67
Textiles	6.53	8.22	5.00
Paper, Pulp.	7.40	8.69	5.33
Chemicals	6.02	11.29	7.33
Ferrous Metals	7.94	9.06	10.00
Non-Ferrous Metals	6.64	8.23	10.00
Metal Products	7.36	**	5.00
Machinery	9.21	7.09	6.00
Electrical Machinery	7.53	7.03	12.00
Transport Equip.	5.88	10.70*	9.67
Other Manufacturing.	9.02	**	**
Services	5.37	**	**

(* U. S. figure for Motor Vehicles only.

(✲✲ No comparable category

(The lag figure for the U. S. were taken from Jorgenson-Stephenson, "The Time Structure of Investment Behavior in U. S. Manufacturing, 1947—1960", The Review of Economics And Statics, February 1967)

(The lag estimates by the Economic Planning Agency are presented in "The Report on Investment ey Major Incorporated Enterprises", 1959)

V. Implications

While the results outlined in the preceeding sections do not represent the results of a coordinated effort at this point in time, nor are they beyond criticism from the point of view of thoroughness, they appear to be important for what they suggest about the behavior of firms, industries and even nations in the context of domestic markets and world trade.

If most products do in fact exhibit decreasing costs, then the firms that are the most aggressive in responding to investment stimuli will reach higher levels of accumulated production before less aggressive firms and therefore will have lower levels of costs. This naturally implies that they will have a strong competitive advantage. Measuring the average speed of response is therefore one method of evaluating the performance of companies in an industry and their likehood of success in a field they have entered. This method may lack reliability over time on the level of the individual firm, since changes in the management could bring large changes in the speed of response. The results obtained from a study of response to investment stimuli are therefore one set of data to be used along with many more in evaluating a firm's performance: They are not to be regarded as as absolute measure.

On a higher level of aggregation the differences observed between the U. S. and Japan have very important implications for the trade between these two nations. If Japan reacts much

more rapidly than the U. S., then it will clearly develop a cost advantage in new areas. Indirect evidence of this is already available, as even a cursory review of the history of Japan U. S. trade relations in recent year will indicate. While being careful not to overmake the point, the speed of response to investment stimuli and decreasing cost have clearly played an important role in a number of industries in Japan and have made these industries the lowest cost producers in the world. Shipbuilding and T. V. sets are but two examples.

These results also have prescriptive significance for international trade policy as well. If costs are a function of total volume, then quite aside from any considerations of absolute or competitive advantage, it is clearly to the advantage of all nations consuming a certain product to concentrate production in one nation. Unlimited concentration in one nation of course raises the question which the results summarised above have avoided. That is does the average cost curve eventually turn up as scale increases. Is there an optimal scale for a product and beyond that costs increase? Although no evidence of this has been presented it is clearly a point to be investigated. If this is not a problem, then it is clear that nations, Japan among them, that insist upon a minimum level of domestic production, if not outright exclusion of some imports, will be paying an ever-increasing price for the goods for which they have opposed concentration of production. These results also clearly argue for international planning in production, aiming at a concentration of production that takes account not only of comparative advantage, but decreasing costs with increasing volume as well.

Footnotes

(1) See Z. Griliches and D. Jorgenson, "Sources of Measured Productivity Change: Capital Input," *American Economic Review*, Vol. 56, May 1966 pp. 50-61.

(2) R. M. Solow, "Technical Change and the Aggregate Production

Function, Review of Economics and Statistics, Vol. 39, August, 1957. pp. 312—320.

(3) See L. R. Christenson and D. W. Jorgenson, "U. S. Real Product and Real Facter Input, 1929—1967", Working Paper No. 154 Univ. of California, Berkeley. 1969.

(4) See references footnotes 1 and 3.

(5) Boston Consulting Group, "On Experience"

(6) D. W. Jorgenson, "Anticipations and Investment Behavior," in J. S. Duesenberry, Gary Fromm, L. R. Klein and Edwin Kuh (eds.), *The Brookings Quarterly Econometric Model of the United States* (Chicago: Rand Mc Nally and Company, 1965), pp. 35—95.

(7) C. T. Ratcliffe, "Investment Behavior in Japanese Manufacturing Industries, 1955—1967," Paper presented at the Third Far Eastern Conference of the Econometric Society, June 1968.

(8) D. W. Jorgenson and J. A. Stephenson, "Investment Behavior in U. S. Manufacturing, 1947—1960," *Econometrica*, 35 (April 1967)