



is Q_2 , Q_3 , or Q_4 would be unsatisfactory to them. In fact it may well be an optimal situation for them. Consider the case where there is a majority shareholder who has appointed a management team to a firm and finds that they run the firm with a degree of X-inefficiency present and seem to be pursuing policies that will result in maximization of, say, sales revenue rather than profits. If the major shareholder's aim is to maximize his income from the firm it would seem that he would find the situation unacceptable, but he must consider what would happen if he attempted to reduce the degree of X-inefficiency and change the management's objectives to his own. Whatever actions he took in an attempt to achieve this aim would involve him in extra costs and expenditure of effort. In some cases it will happen that the current position of the firm will be such that the effort required to alter the situation is greater for the majority shareholder than the benefit he would expect to obtain if his moves were successful. In other words, the situation lies within the shareholder's inert area; so, in spite of the firm's failure to earn maximum profits as a result of the management's pursuing other objectives or failing to minimize costs, the shareholder will be maximizing his utility.

Leibenstein discusses the combined inert area for two groups,⁴

4. *Ibid.*, pp. 608-10.

but illustrates it with management-worker relationships. However, it would seem that exactly the same situation arises if the two groups are shareholders and management.

To sum up, this note suggests that Leibenstein's X-efficiency concept is helpful in showing why many firms do not follow cost-minimizing policies and also in showing why firms will not, even in cases where shareholders could control the management, necessarily move toward profit-maximizing and cost-minimizing policies.

UNIVERSITY OF TECHNOLOGY, LOUGHBOROUGH, ENGLAND

COMMENT ON
THE THEORY AND MEASUREMENT OF
DYNAMIC X-EFFICIENCY *

KEN JAMESON

I. Introduction, 313.—II. The model, 314.—III. Dynamic X-efficiency, 316.—IV. Dynamic X-efficiency in India, 318.—V. The determinants of X-efficiency, 321.—VI. Conclusions, 324.—Appendix A, 325.—Appendix B, 325.

I. INTRODUCTION

Recent investigations of firm and industry behavior have generated an increasing number of observations of decreases over time in average costs of production, with the decreases seemingly not attributable to organizational or technical change. Traditional static theory of production is hard put to explain this phenomenon, which Leibenstein has termed "X-efficiency." His own work in the area suggests changes in effort and effectiveness of managers and workers as a likely explanation.¹

While accepting the significance of X-efficiency for problems of allocation, the present paper suggests a model able to explain the observations on more familiar economic grounds. Since many of the interesting problems raised by X-efficiency are essentially dynamic in nature, e.g., the residual in economic growth and the growth of industries, it is natural to look to a dynamic model for our explanation. The next section of the paper specifies such a model. It has the advantage of focusing on dynamic economic considerations, but in a context that can provide information on the factors highlighted by Leibenstein's work.

Section III presents a more detailed analysis of the view of X-efficiency implied by the model, a view we shall term "dynamic X-efficiency." Section IV presents the estimates of the model for 25 manufacturing industries in India, followed by an examination

* I am indebted to Dr. Jeffrey Williamson for his extensive aid on this project and to Professors Laurits Christensen, Samuel Morley, and Michael Wiseman for their comments. Support was received from the National Science Foundation and the Ford Foundation.

1. See his "Organizational or Frictional Equilibria, X-Efficiency, and the Rate of Innovation," this *Journal*, LXXXIII (Nov. 1969); "Allocative Efficiency versus X-efficiency," *American Economic Review*, LVI (June 1966); and the paper with W. Comanor, "Allocative Efficiency, X-efficiency and the Measurement of Welfare Losses," *Economica*, New Series, XXXVI (Aug. 1969).

of the significance of X-inefficient behavior in that country. Initial investigation of some determinants of X-efficiency comprises Section V, while Section VI contains the conclusions.

II. THE MODEL

A model of industry maximization over time will provide the focus of the paper.² In particular we shall concentrate on the investment demand function derived from the "cost of adjustment" model of industry operation.³ The model will be presented at some length in its estimation form, for an understanding of dynamic X-efficiency requires familiarity with the model itself.

We assume that industries are price takers by virtue of the small country assumption and of price controls such as those existing in India. The industry operates to maximize the present value of its net revenues:

$$(1) \quad \text{Max } V = \int_0^{\infty} e^{-rt} R(t) dt$$

$$R(t) = p(t)Q(t) - w(t)L(t) - u(t)K(t) - c(K'),$$

where V is the present value of net revenue
 R is net revenue
 r is the rate of discount
 $p(t)$ is the price of output in period t
 $w(t)$ is the wage rate
 $u(t)$ is the variable cost of capital (user's cost)
 $Q(t)$ is the rate of output in period t
 $L(t)$ is the labor service input
 $K(t)$ is the capital service input
 $K' = \frac{dK}{dt}$ $K'' = \frac{d^2K}{dt^2}$
 $c(K')$ is the cost of adjustment function.

The functional forms assumed are the following:

$$c(K') = bK'^2$$

$$Q(t) = a_1K(t) + a_{11}K(t) + a_2L(t) + a_{22}L(t)^2$$

$$(a_1, a_2 > 0; a_{11}, a_{22} < 0).$$

The first specification is that commonly used in work on the cost

2. It seems likely that a number of dynamic models could represent X-efficiency with some success. The "learning by doing" model comes to mind immediately. However, the model chosen seems to be particularly appropriate for the Indian case, which is the basis of the empirical investigation of dynamic X-efficiency.

3. The model was first presented by R. Eisner and R. Strotz, "Determinants of Business Investment," in Commission on Money and Credit, *The Impact of Monetary Policy* (New York: Prentice-Hall, 1963). It has been developed more extensively by R. Lucas, "Optimal Investment Policy and the Flexible Accelerator," *International Economic Review*, VIII (Feb. 1967).

of adjustment. It should be borne in mind, as later in the paper the parameter b will be found to play a major role in dynamic X-efficiency. The quadratic production function has its major advantage in imposing minimal constraints on such key production parameters as the elasticity of substitution. Since such constraints seem to affect the results of the models quite significantly and since the information needed to justify such constraints for India is not available, the quadratic is appropriate for our purposes. However, a wide variety of other production specifications could be used without changing the results of this paper in any essential way.⁴

Solution of the industry maximization by calculus of variations yields the following maximization conditions (omitting time subscripts for clarity):

$$(2) \quad e^{-rt} \left[p \frac{\delta Q}{\delta L} - w \right] = 0$$

$$(2') \quad p \frac{\delta Q}{\delta L} = \frac{w}{p}$$

$$(3) \quad e^{-rt} \left[2bK'' - 2brK' + p \frac{\delta Q}{\delta K} - u \right] = 0$$

$$(3') \quad 2b(K'' - rK') + p \frac{\delta Q}{\delta K} - u = 0.$$

The solution of equation (3') provides an investment demand equation of the flexible accelerator variety:

$$(4) \quad K' = \beta [K^*(t) - K(t)]$$

with β the flexible accelerator adjustment coefficient, and K^* the desired stock of capital, found from the particular solution to be

$$(5) \quad K^*(t) = -\frac{a_1}{2a_{11}} + \frac{1}{2a_{11}} \left[\frac{u}{p}(t) \right].$$

The estimating equation is

$$K' = -\frac{\beta a_1}{2a_{11}} + \frac{\beta}{2a_{11}} \left[\frac{u}{p}(t) \right] - \beta [K(t)] + e(t)$$

⁴ This form has been used quite extensively in agriculture production function investigations. See E. Heady and J. Dillon, *Agriculture Production Functions* (Ames: Iowa State University, 1961). It can be taken directly from this literature or as an approximation obtained by a linear expansion about $K=L=0$, with the interaction term set equal to zero. For a more extensive treatment of the function, its close approximation to the Cobb-Douglas function, and the effect of alternative specifications, see the author's Ph.D. thesis, "Adjustment Costs and Investment in the Less Developed Country," University of Wisconsin, 1970. Lucas, *op. cit.*, develops the model using generalized production functions.

$$(6) \quad K' = d_0 + d_1 \frac{u}{p}(t) + d_2 K(t) + e(t),$$

where $e(t)$, the error term, is assumed to have the usual classical properties.

Finally, we note that the solution procedure yields an explicit expression for β , the accelerator adjustment coefficient. This is

$$(7) \quad \beta = \frac{1}{2} \left\{ r + \sqrt{r^2 - \frac{4pa_{11}}{b}} \right\},$$

where all quantities are as defined above.

If the production function is well behaved, i.e., $a_{11} < 0$, the result establishes a useful arithmetic relation between b and β . *Ceteris paribus*, as b approaches infinity, β approaches r as its lower bound; as b approaches 0, β increases without limit. Thus with relatively small variation in r , p , and a_{11} , the estimated value of β can be used as a measure of the costs of adjustment. The later work will concentrate on the estimates of β for this reason.

III. DYNAMIC X-EFFICIENCY

Turning now to a direct treatment of dynamic X-efficiency, we shall define dynamic X-(in)efficiency as operation by an industry in which its dynamically efficient behavior deviates from that required for static efficiency. Thus an industry operating inside of its static production frontier due to dynamic considerations is dynamically X-inefficient.

Reference to equation (3') will clarify the concept. There it is seen that the necessary condition for maximization deviates from the usual comparative static condition of equality between capital's marginal product and its marginal variable cost. Instead of the usual static condition,

$$p \frac{\delta Q}{\delta K} - u = 0,$$

maximization in the dynamic model requires that

$$(3') \quad 2b(K'' - rK') + p \frac{\delta Q}{\delta K} - u = 0.$$

If the first expression in (3') is not zero, there will be a deviation of industry behavior from static maximization behavior; the presence of dynamic factors will cause average costs of production to be higher than in the static case. It should be apparent that a decrease in the absolute value of the expression would result in a

decrease in average costs of production. Such a decline in average costs with no change in production parameters or technical factors is the type of occurrence that has given rise to concern with X-efficiency.

Closer examination of (3') above indicates that for a given rate of discount there can be two causes of dynamic X-inefficiency, and changes in either of them could generate observations of X-efficient behavior. The first of these is the difference $(K'' - rK')$; the second is the quantity $2b$, involving the cost of adjustment parameter. Let us take them in turn.

The first involves the rate of investment and its rate of change and seems the more likely to generate X-efficient behavior. A hypothetical example can illustrate the operation of this factor. Suppose an industry is expanding through net investment at a steady rate ($K'' = 0$), perhaps because it is in an early stage of its development.⁵ Its average costs of production would be higher than under comparative static equilibrium because of its adjustment costs. Now assume that the industry enters a new phase of slower growth and investment, again with $K'' = 0$. Though nothing else changed, the decline in investment would lower the average costs of production; and as the bracketed term approached zero, dynamic and static behavior would coincide. This is X-efficiency, and the model gives an explanation of such an observation based on the growth decisions of the industry.

But is that explanation of the observed behavior anything more than a theoretical possibility? No definitive answer is forthcoming from previous work on X-efficiency, but some indications are there that the rate of investment may be a major factor in X-efficiency. For example, one instance of X-efficiency given by Leibenstein is that "experience in the U.S. industry suggests that adversity frequently stimulates cost reducing attempts, some of which are successful, within the bounds of existing knowledge."⁶ But one of the first effects of "adversity" on industry operation is likely to be a decline in the investment rate. Since this drop in investment would lower adjustment costs, the success of the cost reduction program is quite in accord with the implications of the model. A second indication comes from Harbison's summation of his work, which emphasizes as a major factor in X-efficiency that "industries requiring

5. J. Williamson and J. Kmenta develop a view of industry growth relying on stages in "Determinants of Investment Behavior: United States Railroads, 1872-1941," *Review of Economics and Statistics*, XLVIII (May 1966).

6 "Allocative Efficiency versus X-efficiency," *op. cit.*, p. 405.

large capital investment probably require correspondingly large investment in organization."⁷ In terms of our model, Harbison is verbalizing the result that large investment programs entail large costs of adjustment, with resultant effects on productivity. Thus there does seem to be some awareness of the importance of this factor in X-efficient behavior. In future investigations more direct attention to the investment factor should allow better estimates of its importance.

The remainder of the paper will concentrate on the second constituent of dynamic X-(in)efficiency, the cost of adjustment factor. As noted above, changes in b will generate X-efficient behavior. Though we would expect b to be more stable than K' and thus less important in causing X-inefficiency, the factors underlying changes in b have received the most treatment in the X-efficiency literature. For example, the managerial factor highlighted by Leibenstein would have its primary effect on the value of b in the model as developed.⁸ The emphasis of the next sections reflects the earlier emphases.

IV. DYNAMIC X-EFFICIENCY IN INDIA

Estimates of the adjustment parameter, β , are the focus of the remaining sections. As noted above, they are algebraically related to b and will reflect the influence of the value of b in an industry. To obtain these estimates, equation (6) was estimated for the 25 Indian manufacturing industries listed in Appendix A.⁹ The data used in the estimation are listed in Appendix B, but a few words on the makeup of the sample are in order.

The firms covered in the sample are classified as medium or large public limited companies. These are private joint-stock companies with a paid-up capital greater than R. 500,000 (= \$100,000 at pre-1966 devaluation official exchange rates). Firms were included so as to ensure 80-90 percent coverage of the private industry, with

7. F. Harbison, "Entrepreneurial Organization as a Factor in Economic Development," this *Journal*, LXX (Aug. 1956), 378.

8. Leibenstein would seem to ascribe a much greater role to the managerial factor than simply the determination of the value of the cost of adjustment function. In his work, managers' goals supplant the optimization process that we have assumed.

9. The ideal test of dynamic X-efficiency and the factors affecting it would be carried out in the United States, where data limitations are not so severe and where investment demand studies would provide a clearer context for the investigation. However, since most of the interest in X-efficiency has been exhibited by development economists and in the context of the developing countries, it was decided to use the Indian case.

the firms selected submitting their annual income statements and balance sheets to the Company Law Board. Working from these, the Reserve Bank of India checked the data for consistency and aggregated them to the 25 groups we are using. The care used by the Reserve Bank in collating the data and by the Company Law Board in enforcing the uniform accounting regulations allows some degree of confidence in the data. An examination for inconsistencies and likely biases in the data was made, with no major errors encountered. While some biases may exist, they are relatively minor and are unlikely to have changed over the sample period, 1951-1965.

The data do present one complication, for they are broken into three subsamples of five years each, differing in the number of firms included in each sample. To account for this factor, dummy variables were used in the estimation, allowing each subsample a separate intercept. The model was estimated using ordinary least squares, for no econometric problems were discovered beyond those generally found in investment studies. In fact the absence of a strong time trend in most of the series indicates that the usual serial correlation problem may be of minor importance.

Table I presents the results of the estimation of the model. The coefficients estimated are as follows: d_{0i} denotes the estimate of the intercept for the i -th subsample ($i=1, 2, 3$); d_1 is the estimate associated with the definition of the desired stock of capital, which in this case is the user's cost variable; d_2 is the capital stock parameter and is the negative of the flexible accelerator coefficient.

A brief examination of the estimates indicates that the model specification in the flexible accelerator form yields acceptable results. Of the d_2 estimates, 21 of 25 have the correct sign and 16 of 25 are statistically significant. The results on d_1 were not so successful; however, investigation of two alternative specifications of the desired stock of capital, differing on theoretical grounds, improved the results significantly.¹ Since these changes had little effect on the d_2 estimates, which are our major concern, they will not be presented.

Examination of the results indicates that the size of the adjustment cost effect on dynamic X-efficiency varies considerably over Indian industries. Industry 307, rayon textiles, shows the smallest

1. The two alternate forms were specification of a fixed factor production function that introduces the level of output into the desired stock of capital, and omission of tax considerations from the user's cost of capital to account for the effect of managing agents. Complete results appear in the author's Ph.D. thesis, *op. cit.*

TABLE I

Industry	d_{01}	d_{02}	d_{03}	d_1	d_2	R^2	DW
201	0.0058	0.0052	-0.0067*	0.0514**	0.2858	0.66**	1.7
299	-.0030**	-.0023**	.0017**	.0028	-.4156**	.48*	1.9
301	-.0019***	-.0008***	.0014***	.0015***	-.8988***	.90***	2.4
302	-.0039*	-.0358	.0032*	.0029	-.5281*	.34	1.6
303	-.0284***	-.0185	.0178***	-.0066*	-.3279***	.77***	1.4
304	-.0062***	-.0030***	.0036***	.0022	-.7522***	.91***	2.1
305	-.0673***	-.0528**	.0408**	-.0557	-.0887	.75***	2.0
306	-.0084	-.0056	.0063*	.0297*	-.1681*	.49*	1.9
307	-.0516***	-.0419***	.0311***	-.0049	-.9021***	.83***	1.0
399	-.0036**	-.0032**	.0018	.0102	-.0177	.53**	2.0
401	-.0882	-.0463**	.0719***	-.5481	-.3554***	.81***	2.4
402	-.0211***	-.0240***	.0114***	.0124*	-.5052***	.86***	1.9
404	-.0134**	-.0101**	.0059*	.0306	.0122	.83***	1.9
405	.0166***	.0152***	-.0093***	.0102	.5165***	.97***	2.1
406	-.0085*	-.0046*	.0061**	-.0411	.0193	.62**	2.3
409	-.0453***	-.0414***	.0241***	-.0070	-.2596***	.80***	1.6
410	-.0095***	-.0022***	.0050***	.0011	-.2561***	.89***	1.8
411	-.0024	-.0015	.0013	-.0005	-.1431	.37	2.0
412	-.0002	-.0001	.0002	.0037*	-.1773	.45*	1.3
499	-.0003	.0031***	.0004	-.0017	-.1360**	.86**	2.4
502	-.0216***	-.0111	.0105**	.1793**	-.3175*	.59**	1.7
503	-.0053***	-.0043**	.0032***	-.0071**	-.3532***	.63***	2.0
504	-.0089***	-.0072**	.0050***	-.0070	-.2774**	.51**	2.1
505	-.0095*	-.0218***	.0033	.1536**	-.0954	.64***	2.1
599	.0025	-.0099	.0065	.1144	-.5540***	.45*	2.4

a. DW is the Durbin-Watson Statistic; ' denotes a value in the inconclusive range.
 Significance levels: ***: 0.01
 **: 0.05
 *: 0.10.

deviation of dynamic from static efficiency, as it completes 90 percent of its adjustment within one year ($d_2=0.90$). At the other extreme is Industry 399, miscellaneous light manufacturing, with an adjustment coefficient of 0.017. The low value is indicative of very high adjustment costs and consequent large deviation from static efficiency.

In the overall results it is found that the arithmetic average of the adjustment coefficients for the 21 industries having the proper sign is 0.3585, with 7 industries above the average and the rest below. An average weighted by industry size or by investment would be much lower, for the 3 major industries — cotton textiles, sugar processing, and iron and steel — are all below the mean. In terms of adjustment, the 0.3585 value implies that 57 percent of the adjustment to a new desired stock of capital would be completed in 2

years, while on the average it would take 7 years to close 95 percent of the gap.

One means of gaining a better understanding of the relative degree of dynamic X-efficiency in India is to compare these results with those of investment demand studies of United States manufacturing industry. In the study whose coverage most closely resembles the present one,² the average lags estimated for the U.S. industries are almost uniformly smaller than those we have found. The average of these lags over industries is smaller; and in the cases common to the two studies, no Indian industry exhibits an average lag smaller than the corresponding American industry, with the difference in some cases quite large. This result provides evidence that the degree of dynamic X-inefficiency due to adjustment costs is greater in India than in the United States. Other evidence from the United States points in the same direction. Nadiri and Rosen find an implied overall adjustment coefficient of 0.40 in their study of aggregate investment, again yielding a smaller lag for the United States.³ Eisner and Nadiri obtain an adjustment coefficient of 0.48 and indicate that Jorgenson and Stephenson may have underestimated the speed of adjustment in the United States by their estimation constraints.⁴ Again the results uniformly point to more rapid adjustment in the United States, results consistent with the view that there are smaller adjustment costs and less dynamic X-inefficiency in the United States.

V. THE DETERMINANTS OF X-EFFICIENCY

The remaining concern of the paper is an initial investigation of two possible determinants of the degree of dynamic X-inefficiency reflected in the adjustment parameters.⁵ Several explanations of X-inefficient behavior have been advanced, but no coherent empirical information has been available to date. The estimates presented in Section IV provide such information. They will be compared over

2. D. Jorgenson and J. Stephenson, "The Time Structure of Investment Behavior in United States Manufacturing, 1947-1960," *Review of Economics and Statistics*, XLIX (Feb. 1967).

3. "Interrelated Factor Demand Functions," *American Economic Review*, LIX (Sept. 1969).

4. "Investment Behavior and Neo-classical Theory," *Review of Economics and Statistics*, L (Aug. 1968).

5. A variety of likely determinants suggest themselves. Eisner and Strotz, *op. cit.*, concentrated on the degree of imperfection in capital goods markets. Alchian has recently suggested that "information costs" may explain costs of adjustment. (A. Alchian, "Information Costs, Pricing, and Resource Unemployment," *Western Economic Journal*, VII (June 1969).)

industries, and the differences between industries will provide evidence on likely causes of X-inefficiency.

The first factor to be investigated is the incompatibility between imported capital goods and the production environment that they are to be used in.⁶ Imported machinery often has a design that is inappropriate for operation with available complementary production factors, necessitating redesign of the production facilities or adaptation of the equipment. This entails a cost to the industry associated with its investment, and the cost is likely to rise at a more rapid rate than the increase in investment. Thus the cost of adjustment specification seems appropriate.

In testing this factor, there are no series available on "incompatibility" per se. Instead, a proxy that should be closely related to incompatibility will be used. It is a measure of technical interdependence between a given industry and the other industries in an input-output table (see Appendix B). An increase in interdependence would be likely to raise the degree of incompatibility between new equipment and the rest of the production environment. Thus adjustment costs would be higher and adjustment slower, implying that technically complex industries would be more X-inefficient in the dynamic sense.

The second factor is a familiar one in development literature, much of which is concerned with the effect of limited managerial ability on development. Leibenstein's work is the best example of this emphasis.⁷ Knowledge of India indicates that the strains on managers in the post-independence period of rationalization and modernization of industry were very large. There were widespread changes in the methods of production as well as in the types of production and the organization of industry. Thus we could expect costs due to managerial problems to be quite significant, and they should be greatest in those industries that were well established in a traditional pattern at the time of independence. Such industries were likely to be run by managers of an outmoded "vintage." Given the predominance of family ownership in Indian industry, the older-vintage managers were not forced out during rationalization, but were maintained by family ties. As a result the well-established

6. J. Baranson has done extensive work on this question: *Manufacturing Problems in India: The Cummins Diesel Experience* (Syracuse University Press, 1967); *Industrial Technologies for Developing Economies* (New York: Praeger, 1969).

7. Especially in "Organizational or Frictional Equilibria, X-Efficiency, and the Rate of Innovation," *op. cit.* We should note that the measure used to capture the managerial effect is again a proxy and cannot be considered to capture all the aspects of managerial effort and ability that he mentions.

industries should exhibit higher adjustment costs and slower adjustment.

The tests of these factors are preliminary and indicative; however, the results point to their importance in determining the degree of X-inefficiency. Comparison of the estimated adjustment coefficients over industries provides the evidence.

At a very general level, the difference in adjustment coefficients between the United States and India, which was noted above, is consistent with hypotheses based on these factors. India is likely to be hampered by managerial factors to a greater extent than the United States, and her reliance on imported capital goods should entail costs not important in the United States. Thus the slower speed of adjustment in India is quite as would be expected.

More direct evidence is available as well. The vintage view of managers implies that older industries would exhibit slower adjustment, holding technical factors constant. In the several industries where such a comparison is possible, the results are striking. The two clearest cases⁸ are cotton textiles ($d_2=0.088$) and jute textiles ($d_2=0.16$) versus the newer rayon textiles ($d_2=0.902$), and iron and steel ($d_2=0.355$) versus the newer aluminum ($d_2=0.505$). In both cases the industry well established at independence exhibits slower adjustment. In most other cases it is not possible to hold other things equal, but there seem to be no cases even remotely contrary to the present results. Thus some confirmation that older industries adjust more slowly is apparent, a result consistent with the expectation that old-vintage managers will raise a firm's adjustment costs.

Confirmation of our hypothesis is again evidenced by an examination of the technical complexity factor. An increase in technical complexity is hypothesized to be associated with a decrease in the speed of adjustment. To test this, the industries were ranked according to their speed of adjustment, and this ranking was correlated with another based on a technical complexity index. The Spearman rank correlation test shows the rankings significant at the 0.05 level, and the direction of correlation is as expected. Additional confirmation is obtained by dividing the industries into "key" and "nonkey" groups, following categories set by the Indian government (see Appendix A). Thirteen of the 25 industries are in the first group, 12 in the second. The key industries are generally

8. Additional confirmation may come from a comparison of sugar ($d_2=0.328$) with tobacco ($d_2=0.75$), though neither the age nor the technical factors are completely acceptable for the comparison.

import substitution industries whose technical interdependence is relatively large for Indian industry. Of these 13 industries, only 1 yields an adjustment coefficient above the mean. The remainder adjust slowly, just as expected from consideration of their greater technical interdependence.

While no one of these tests is conclusive, their uniform consistency with our hypotheses allows a presumption that managerial factors and those associated with technical interdependence are major determinants of costs of adjustment and dynamic X-(in)efficiency.

VI. CONCLUSIONS

A dynamic model of industry growth was found to provide an explanation of observed "X-efficient behavior." There are two dimensions to dynamic X-efficiency, the level of investment (and its rate of change) and the costs of adjustment associated with investment. Some indirect evidence suggests the importance of the first factor in generating observations of X-efficiency. The second factor was estimated from a model of investment demand, yielding the conclusion that the degree of dynamic X-inefficiency varies greatly over Indian industries, but is generally higher there than in the United States. Finally, two factors that are likely to affect adjustment costs were investigated, managerial influence and technical interdependence. Both were found to be significant determinants of dynamic X-inefficiency, lending support to more descriptive work by Leibenstein and by Baranson.

This paper suggests that further investigations of dynamic X-efficiency would be very fruitful in providing additional information on differences in X-efficiency over industries and over countries. The results obtained here point to the importance of dynamic X-efficiency in questions of resource allocation. Additional information on other industrial situations, combined with more extensive investigation of the determinants of dynamic X-efficiency, will allow more precise determination of the magnitude of X-efficiency and the potential for conscious operation on it.

Copyright of Quarterly Journal of Economics is the property of MIT Press. The copyright in an individual article may be maintained by the author in certain cases. Content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.