

**Economic "Natural Selection"  
and the Theory of the Firm**

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## ECONOMIC "NATURAL SELECTION" AND THE THEORY OF THE FIRM

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### I. INTRODUCTION

In discussions of the role of the assumption of profit maximization in the economic theory of the firm, reference is often made to the Darwinian principle of "survival of the fittest." It is argued that, in the economic sphere, the "fittest" are the profit maximizers. The competitive struggle for survival will tend to eliminate from the economy the firms which fail to conform to the profit maximization assumption. Theories based on that assumption may therefore have empirical relevance and validity even if the assumption is highly imperfect as a description of the motives and decision making procedures of managers and entrepreneurs. In its typical role in the economic literature, this argument has served as a line of defense of the standard theory of the firm against attackers who argue that the fundamental assumption of the theory fails to correspond to the observable realities of decision making in firms.

The classic statement of this "survival argument" was made by Armen Alchian in his 1950 article, "Uncertainty, Evolution, and Economic Theory."<sup>1</sup> For the most part, the discussion of the argument since that time has been fragmentary, consisting of a few sentences here and a paragraph there, written either in praise or in condemnation.<sup>2</sup> In spite of the frequent references to

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1. Armen A. Alchian, "Uncertainty, Evolution and Economic Theory," Journal of Political Economy, Vol. 58 (June 1950), pp. 211-222. The original stimulus for the present paper was derived from Alchian's provocative work on this subject. (Subsequent citations to Alchian are to this article, as reprinted in R. Heflebower and G. Stocking, eds., Readings in Industrial Organization and Public Policy (Homewood, Illinois: Richard D. Irwin Co. for the American Economic Association, 1958), pp. 207-219.)

2. Among the non-fragmentary discussions, one may cite: Milton Friedman, Essays in Positive Economics (Chicago: The University of Chicago Press, 1953), pp. 19-23; and Edith T. Penrose, "Biological Analogies in the Theory of the Firm," American Economic Review, Vol. 42 (Dec. 1952), pp. 804-819. Also, the comments on the Penrose article by Alchian and Stephen Enke, and the rejoinder by Penrose, American Economic Review, Vol. 43 (September 1953), pp. 600-07 (cited as Alchian, Enke, Penrose). There is a short (and, it will be argued, unsatisfactory) analysis of the problem in G. S. Becker, "Irrational Behavior in Economic Theory," Journal of Political Economy, Vol. 70 (February 1962), pp. 1-13. For very brief but valuable remarks on the problem, see T. C. Koopmans, Three Essays on the State of Economic Science (New York: McGraw Hill Book Co., 1957), pp. 139-142; and G. C. Archibald, "The State of Economic Science," British Journal of the Philosophy of

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the argument in the context of methodological controversy, Alchian's contribution has attracted little attention as a matter for theoretical examination in its own right. In this paper, the attempt is made to examine systematically the implications of the "natural selection" mechanism and to determine the extent to which the selection argument lends support to the conventional theory of the profit maximizing firm—or, alternatively, the extent to which it leaves the door open to marginally or drastically different approaches to the problem of theorizing about the behavior of firms.

A. Criticisms of the Assumption of Profit Maximization

It will be helpful to begin by summarizing the common lines of attack on the assumption of profit maximization, since the first goal of the present inquiry is to evaluate the effectiveness of the selection argument as a defense against these attacks. I classify the lines of criticism into three broad categories: The first line of criticism argues that it may be appropriate to consider firms (more precisely, their top decision makers) as having goals, but it is not in general appropriate to assume that the goals are well summarized in the phrase "maximization of profits." The second line of criticism argues that it is unreasonable to speak of firms as having goals (i.e., a preference ordering on the states of the world) at all, and a fortiori that it is unreasonable to speak of them as having the goal of profit maximization. The third line of criticism emphasizes the impossibility of profit maximization on the ground that the information and information processing requirements of profit maximization in a world of continuous dynamic change are patently in excess of the resources for obtaining and processing information that are available to real world firms.

There are several lines of argument that converge in the conclusion that a single minded devotion to profits is not likely to characterize the top decision makers of firms. Of particular importance is the classic observation that ownership and control are separated in the modern large corporation.<sup>1</sup> The stockholders, who as the residual claimants on the income stream generated by the firm may be presumed to have a strong interest in profits,<sup>2</sup>

Science, Vol. 10 (May 1959), pp. 58–69. The recurring pattern of remarks on the argument that go little beyond mere allusion to its existence may be illustrated by the methodological discussion before the 1962 meetings of the American Economic Association: American Economic Review, Vol. 53 (May 1963), pp. 230 (Simon) and 235 (Samuelson). Portions of the analysis in the present paper were presented (under the same title) to the Econometric Society in December 1960. That paper was circulated by The RAND Corp., Santa Monica, California (P-2116, December 1960), and is abstracted in Econometrica, Vol. 29 (July 1961), p. 457.

1. A. A. Berle, Jr., and G. C. Means, The Modern Corporation and Private Property (New York: The Macmillan Co., 1933).

2. More precisely, the stockholders may be presumed to have a strong interest in dividends and in appreciation of the price of the stock.

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have only a tenuous control over the selection of the top management of the firm, and no direct control over such "details" as price and output determination or investment policy.<sup>1</sup> The salaried managers who do exercise the direct control over these matters may be presumed to have preference functions which do not depend on profits alone—in particular, it is strongly argued that the salaries and security of such managers depend on the growth of the firm, as measured by the increase in its total revenue.<sup>2</sup> Also, the executives of large corporations are not indifferent to their prestige in the community, and it seems unlikely that this prestige is uniquely and positively related to the level of the firm's profits.<sup>3</sup> Still other objectives may compete with profits in the executive's utility function, e.g., as Hicks suggested, the desire for a quiet life.<sup>4</sup>

However, one need not appeal to the case of the large corporation in order to bring into question the motivational assumption of profit maximization. To predict that the behavior of the owner-manager of a retail store is consistent with the assumption of profit maximization is to predict that he eats, sleeps, watches television and plays with his children only to the extent that will maximize his efficiency as the manager of his store. If any of these activities enter his utility function in their own right, he will not behave as a profit maximizer but will to a certain extent sacrifice profits to the attainment

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1. See R. A. Gordon, Business Leadership in the Large Corporation (Washington: The Brookings Institution, 1945), especially Chapter VIII, for a discussion of the influence of the stockholders on the decision process. Also, A. G. Papandreou, "Some Basic Problems in the Theory of the Firm," in B. F. Haley, ed., A Survey of Contemporary Economics, Vol. II (Homewood, Illinois: Richard D. Irwin Co. for the American Economic Association, 1952), pp. 183-219. Papandreou summarizes the evidence on various external influences on decision makers in firms, and in general provides an excellent statement of the point of view now being summarized.

2. In particular, this is the thesis developed by W. J. Baumol, Business Behavior, Value and Growth (New York: The Macmillan Co., 1959), especially, in Chapter 6.

3. Of particular relevance in this connection is the rise of a business ideology which emphasizes the responsibilities of corporate management toward consumers, labor and the community at large rather than toward stockholders alone. See F. X. Sutton, with Harris, Kaysen, and Tobin, The American Business Creed (Cambridge: Harvard University Press, 1956). See also Milton Friedman, Capitalism and Freedom (Chicago: Phoenix Books, 1962), pp. 133-36, where it is strongly argued that the new business creed is incompatible with the basic principles of capitalism.

4. J. R. Hicks, "The Theory of Monopoly," Econometrica Vol. 3 (Jan. 1935), pp. 1-20.

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of other goals.<sup>1</sup> In general, then, it appears to be highly doubtful that the motivations of the managers of firms are adequately summarized as a desire for maximum profits.

The second line of argument mentioned above denies that a firm (or its management) has goals at all in the sense of there existing a preference ordering on states of the world such that the firm's decisions always amount to the choice of the most preferred attainable situation. The typical response to the highly complex decision problem confronting a large organization—with the attendant uncertainties, the necessity for dividing the task of decision making among several individuals, and so forth—is said to be a process of search which terminates when some satisfactory solution to the problem is found, rather than when an optimal solution is found.<sup>2</sup> Indeed, since the decision problem confronting a firm is not fully structured for it a priori, as the traditional theory of the firm assumes it to be, the search for an optimum position would be of indeterminate length and the notion that the firm searches for such a position is either meaningless or hopelessly impractical.<sup>3</sup> Thus, what is crucial in predicting the behavior of the firm is an understanding of the dynamics of its search processes and of the influences which determine the sort of solution that is considered "satisfactory."

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1. For more extensive analyses from a similar point of view, see T. Scitovsky, "A Note on Profit Maximization," Review of Economic Studies, Vol. 11 (Winter 1943), pp. 57-60; M. Reder, "A Reconsideration of the Marginal Productivity Theory," Journal of Political Economy, Vol. 55 (Oct. 1947), pp. 450-58; B. Higgins, "Elements of Indeterminacy in the Theory of Non-perfect Competition," American Economic Review, Vol. 29 (Sept. 1939), pp. 468-479.

2. This is the view that firms are satisficers rather than maximizers. See H. A. Simon, "A Behavioral Model of Rational Choice," Quarterly Journal of Economics, Vol. 69 (February 1955), pp. 99-118. A similar view (though stated in a narrower context) was advanced by R. A. Gordon, "Short Period Price Determination in Theory and Practice," American Economic Review, Vol. 38 (June 1948), pp. 265-288.

3. It is this consideration which constitutes the basic objection to any attempt to subsume satisficing behavior as a special type of maximizing behavior that is appropriate for certain "optimum search" problems. Of course, as pointed out above, any behavior can in one way or another be rationalized as maximizing behavior. But to identify satisficing behavior with optimum search behavior is merely to push the crucial problem back a stage: How does it happen that the task of learning about the relevant probability distributions, the ability to identify the problem as one requiring a certain type of search procedure, and the ability to determine the precise procedure required, are within the limited information obtaining-and-processing resources of the decision maker? This point is discussed further in Section V.

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A further reason for doubting that firms can be regarded as having consistent preference orderings is the fact that, except in the smallest firms, more than one person is generally involved in the decision process. (The concept of more than one person being involved in the decision process may be taken to mean that no single individual's preferences are controlling of the firm's decision in every situation.) The interests (as summarized in utility functions) of these individuals are in general not identical; for example, each of several vice presidents or other executives of a company may aspire to the presidency. There must then exist some procedure for compromising the differences among the decision makers or determining whose preferences shall be controlling when any particular issue is faced. It is well known that some common procedures for arriving at group decisions, e.g., majority rule, do not necessarily display the properties of completeness and transitivity that are required if a preference function is to be imputed to the group as a whole.<sup>1</sup> Thus it is at least doubtful that the procedures actually employed yield results such that the firm as a whole can be regarded as acting rationally. And since divergence of interests implies concern with matters other than the firm's profits, it is still less probable that the firm as a whole can be regarded as acting rationally in the pursuit of profits.

The third line of criticism emphasizes the limitations on the information available to the decision makers and the consequent impossibility of profit maximization. Criticism of this type is obviously most relevant to the completely static, perfect information versions of the theory of the firm. Once it is recognized that real world firms operate in a context in which the profit implications of alternative courses of action are imperfectly known, it is usually considered necessary to replace the concept of profit maximization by some concept of utility maximization over alternative probability distributions of profits. But there is no choice for such a utility function which has obvious descriptive realism, and the behavior predicted depends on the choice that is made.<sup>2</sup> Still further complications are introduced when it is recognized that

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1. I am suggesting here that the problem of arriving at a "firm welfare function" which the firm can be considered to maximize has some points in common with the problem of arriving at a "social welfare function" that meets certain criteria of reasonableness. (The formulation of the latter problem, and the demonstration that for some plausible criteria it has no solution, is due to K. J. Arrow, Social Choice and Individual Values (New York: John Wiley & Sons, Inc., 1951).) However, the two problems are not identical. For present purposes the emphasis is not on whether there exists a firm welfare function that depends on the preferences of individual decision makers in certain ways, but on the fact that certain appealing and often-practiced ways of reaching group decisions (such as majority rule, flipping a coin, "taking turns," "logrolling") do not in general give rise to a pattern of decisions that is consistent with any preference ordering.

2. G. Tintner has provided what is probably the most general formulations of

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the firm can act to reduce the uncertainty with which it is confronted, but that such action—the acquiring of more information—is generally costly. For this means that the costs of obtaining and processing the information required for a close approach to a profit maximizing price and output policy (for example) may outweigh the benefits of such close calculation, so that a firm which maximized profits without regard to information costs would not actually be maximizing profits at all. If so, the price and output policy of a firm which actually pursued maximum profits could not be predicted without reference to the costs of obtaining and processing information, and the traditional formulations of the theory of the firm have no room for these costs.<sup>1</sup>

An alternative approach to the problem posed by uncertainty is to assume that the attempt is made to maximize profits on the basis of some “best guess” as to what the future holds, but that the resulting policy is then qualified in some way by a concern with the possibility of unfavorable outcomes. Again, there is a considerable range of choice as to the particular assumptions which would capture the essence of this type of decision making process.<sup>2</sup>

the decision problem facing the firm when the profit implications of different courses of action are imperfectly known: “The Theory of Choice under Subjective Risk and Uncertainty,” *Econometrica*, Vol. 9 (July-October 1941), pp. 298–304; “A Contribution to the Non-static Theory of Production,” in *Studies in Mathematical Economics and Econometrics*, Lange, McIntyre and Yntema, eds. (Chicago: University of Chicago Press, 1942). A noteworthy but little noticed aspect of Professor Friedman’s methodological position (*op. cit.*) is his comment in a footnote (note 16, p. 21) to the effect that he uses the term “maximization of expected returns” to cover behavior consistent with maximization of any utility function over probability distributions of returns. I am not aware of any empirical work in which refutable implications with respect to market behavior of this very general hypothesis are subjected to test; indeed, it is hard to think of examples of theoretical work in which such implications are developed. If taken seriously, this interpretation would place Friedman’s position very close to complete, tautological, subjectivism. (See subsection B.) But he does not avail himself of this wide open escape route; he seems to say that he is willing to take his risks with the success or failure (to a tolerable approximation!) of the market implications of the statical, perfect information version of price theory.

1. Some recent theoretical work does make room for them, however, particularly the “economic theory of teams” developed by J. Marschak, R. Radner and others. For an introduction to the basic concepts of this theory, see J. Marschak, “Theory of an Efficient Several-Person Firm,” *American Economic Review*, Vol. 50 (May 1960), pp. 541–48.

2. See the discussion of this approach in William Fellner, *Competition Among the Few* (New York: Alfred A. Knopf, Inc., 1949), pp. 146–157. Fellner suggests that a concern for “safety margins” may be at least a partial explanation for the practice of average cost pricing. The specific model of an economic selection process presented in Section IV below seems to lend some support to this argument, although, strictly speaking, the conclusions developed there relate to the output policies of competitive firms rather than to the price-output policies of monopolistically competitive firms.

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The implications of imperfect and costly information go still farther. The entire problem of oligopolistic interdependence, with the attendant ambiguities in the concept of a profit maximizing price and output policy, can be subsumed under this heading: It is the absence of well founded information as to the responses that the firm's rivals will make that makes it difficult to structure the problem facing the firm. Imperfections in information also reinforce the observation that the goals of particular managers may not coincide with the goal of maximum profits for the firm. The vice president who aspires to the presidency of the company may, without being detected, sacrifice the profits of the company to his own ambitions—as when he conceals his past mistakes. They include the fact that stockholders cannot learn whether the depressed profits of a company are the result of factors over which the management has no control, or whether they reflect the fact that the management is pursuing objectives other than profits—the quiet life and the respect of the community. In general, the fact that the stockholders cannot “check up” with perfect effectiveness on the actions of the president, or the president on the actions of the vice presidents, and so on, means that individuals are to some extent free to pursue their own goals at the expense of the profits of the firm.

### B. Replies to the Criticisms

In addition to the selection argument itself, there are two prominent points of view which dispute the relevance or persuasiveness of the foregoing criticisms. The first of these, which is particularly associated with the name of Milton Friedman,<sup>1</sup> simply denies that any information or argument which relates to events within firms has any bearing on the adequacy of the assumption of profit maximization as the basis for the economic theory of the firm. The second position is less clearly delineated and more widely held; the common thread running through the various arguments is that the necessary modifications in the theory of the firm can and should be made without discarding the fundamental assumption of profit maximization.

Since Professor Friedman's methodological position on the role of assumptions in economic theory has attracted and continues to attract a great deal of attention and criticism, I will not go into detail here on the issues involved. The most succinct statement of the Friedman position (as it relates to profit maximization) would seem to be that the theory of the firm is misnamed; it is not a theory of the firm at all in the sense of being useful for prediction of events within any particular firm. The theory of the firm is a theory of the external (market) behavior of the firm; more importantly, it is a building block in the theory of firms, i.e., the theory of how firms in the aggregate will react to market situations. Thus, in particular, the theory of the firm does not predict the answers that decision makers in firms will give when queried about their objectives, nor does it predict how they will go about reaching their decisions. This being the case, how can evidence on these points be relevant to a judgment about the predictive power of the theory? Clearly, says Friedman, it cannot. But the theory does yield hypotheses about what will be observed in

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1. Friedman, op. cit.

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market situations; for this purpose, Friedman says, it has served well, and there are no appealing substitutes for it.<sup>1</sup>

In considering this position, the first and central issue to be confronted is whether it is legitimate to protect the assumption of profit maximization from test on the basis of evidence relating to the internal workings of firms. As against the legitimacy of putting such a shield around the assumption of profit maximization, it may be observed that the theory of the firm certainly can be read as saying something about the internal workings of firms. Suppose, for a moment, that the various studies which have been made of the goal and procedures of decision makers in firms had consistently arrived at the conclusion that top decision makers obtain some summary of production possibilities and costs from the production department, a review of the market situation from the sales department, and then set about investigating price and output policies with a view to finding the one that would yield maximum profits. Would Friedman, or anybody else, have then argued that whatever the interest in these conclusions might be, they had no bearing on the acceptability of the assumption of profit maximization and the rest of the traditional theory? It seems safe to say that such evidence would have been enthusiastically received by one and all as indicating the fruitfulness and the predictive power of traditional formulations. Thus the auxiliary hypothesis which restricts the predictive range of the traditional theory to market phenomena is an *ex post* amendment to the theory; furthermore, it is not an amendment that suggests a new range of testability for the theory as amended, but one that rules out tests considered *ex ante* to be appropriate. The introduction of auxiliary hypotheses of this type is not the path to a cumulative increase in knowledge.<sup>2</sup>

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1. The position just set forth is my own reading of Friedman, which is certainly not the only possible one. As compared with the recent discussion by Professors Nagel, Simon, and Samuelson (E. Nagel, "Assumptions in Economic Theory," and discussion by P. Samuelson and H. Simon, *American Economic Review*, Vol. 53 (May 1963), pp. 211-19, 229-231, 231-36 respectively), it is more charitable in that it does not involve the following charges: (1) That he fails to understand that the assumption of profit maximization implies itself (see Friedman, *op. cit.*, p. 28). (2) That he commits a logical error by arguing that when A implies B, and B is found to be true, A is true (I take him to mean only that the truth of B leads us to "accept" the hypothesis A in the usual statistical sense of "cannot reject hypothesis A on the evidence B"). (3) That he clings to A even though it is known to be false, on the ground that it successfully predicts B and that makes it useful, though false. (This is one possible reading; my own is that A cannot be shown to be false because it has no empirical counterpart; a third is that the alleged evidence against A is by no means conclusive.)

2. See Karl R. Popper, *The Logic of Scientific Discovery* (English edition; New York: Basic Books, Inc., 1959), especially Section 20, on the question of the admissibility of auxiliary hypotheses. Also, the following quotation (p. 42) is curiously apropos: "According to my proposal, what characterizes the empirical method is its manner of exposing to falsification, in every conceivable way, the

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But even if Friedman's methodological essay had antedated the studies which produced the evidence he dismissed as irrelevant, his position would still be of dubious validity. For, as Friedman correctly stated, the possible hypotheses consistent with any given collection of observed facts are infinite in number, and for the choice among the hypotheses consistent with the facts the criteria are "simplicity" and "fruitfulness."<sup>1</sup> A theory "is more 'fruitful' the more precise the resulting prediction, the wider the area within which the theory yields predictions, and the more additional lines for further research it suggests."<sup>2</sup> It can hardly be argued that the addition of an auxiliary hypothesis providing a narrower definition of the "class of phenomena the theory is designed to explain" is a step in the direction of greater fruitfulness, though it may well be necessary for consistency with the observed facts. We would certainly prefer a theory which predicted the market behavior of firms and the results of direct study of their decision processes to one which predicted only the former; furthermore, this wider range of prediction would increase our confidence in the ability of the theory to predict market behavior in new situations. Thus the auxiliary hypothesis needed to make the theory consistent with the evidence relating to the internal workings of firms can at best be viewed as a temporary expedient which should be indulged in for the shortest possible length of time. Friedman, however, gives the impression of being prepared to indulge in it indefinitely.

The second type of defense of the profit maximization assumption to be considered here is that which argues that any modifications in the theory of the firm necessitated by evidence on their internal workings (or any other evidence) can and should be made without dropping the assumption of profit maximization. In one extreme formulation, this view simply involves a blanket assertion of willingness to make the necessary modifications, so that any and all behavior could be "explained" by imputing to decision makers the beliefs which would make their actual choices profit maximizing ones. This view reduces the assumption of profit maximization to a tautology, which of course deprives it of any refutable implications.<sup>3</sup> There is a very faint but still noticeable family resemblance between this extreme view and the implicit

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system to be tested. Its aim is not to save the lives of untenable systems but, on the contrary, to select the one which is by comparison the fittest, by exposing them all to the fiercest struggle for survival."

1. Friedman, op. cit., p. 10.

2. Loc. cit. Friedman's definition of "simplicity" is rather less satisfactory than his definition of fruitfulness. On the problem of defining "simplicity," cf. Popper, op. cit., chap. vii.

3. Professor Machlup advanced something very close to this extreme subjectivist position in the "Lester-Machlup debate" of 1946-47. See "Marginal Analysis and Empirical Research," American Economic Review, Vol. 36 (September 1946), pp. 519-554. Also, "Rejoinder to an Antimarginalist," American Economic Review, Vol. 37 (March 1947), pp. 148-154.

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or explicit rationale of much of the theoretical work of recent years, work which achieves ever more complex statements and/or solutions of the maximization problem assumed to confront the firm: If the firm has imperfect knowledge of the consequences of its actions, some subjective probabilities and a utility function over the various probability mixtures of outcomes must be imputed to it. If its actions at one point in time affect the alternatives open to it at a later time, sequential decision theory is called for. If it produces a large number of products with large numbers of fixed and variable inputs, some linear or non-linear programming model is appropriate. And so on.<sup>1</sup>

Much of the theoretical work of this type can be readily defended on the grounds of its present or possible future usefulness in the normative economics of the firm, i.e., in management science or operations research applications. But to the extent that such models are offered as a contribution to positive economics, they often have major defects. The most elaborate of them are still drastic oversimplifications of the decision problems facing the larger firms in the real world, but at the same time the problem of estimation they present to an economist actually interested in predicting the behavior of one or more firms is overwhelming. Indeed, many such models incorporate as basic data representations of the beliefs or goals of the decision makers which are indeterminable in practice, if not in principle. Finally, it is frequently the case that the model has so many parameters to be estimated as to make further simplifying assumptions a practical necessity, with the result that the apparent benefits from a more "realistic" statement of the problem are lost.

C. What Difference Does It Make?

If there is a real issue involved in the controversy over the assumption of profit maximization, it assuredly does not center on the question of whether the assumption is consistent with observed fact. For, taken by itself, the assumption does not yield any predictions about behavior,<sup>2</sup> and thus the assumption itself cannot possibly be refuted by any observation. Refutable propositions result only when the assumption is supplemented by some characterization of the decision problem the firm is assumed to face, and of the constraints on its solution to that problem. Even when such a characterization is provided, the predictions that can be made without quantitative information on the problem the firm faces are meagre.<sup>3</sup> Still

1. Examples of theoretical contributions of this type are so abundant that citation of any of them would necessarily involve an unintended invidious comparison with the others.

2. It might be regarded as being fundamentally an assumption about motivation, in which case it would yield predictions about behavior in response to interview questions about motivation—at least, it would if the interview were conducted with the help of a polygraph. But, by itself, it yields no conclusions about actual economic behavior, whether it is valid as an assumption about motivation or not.

3. See G. C. Archibald, "The Qualitative Content of Maximizing Models" (forthcoming).

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further assumptions must be made if such quantitative information is to be obtained, since real world counterparts must be found for more of the entities in the theory. At any one of these stages, a determined defender of the profit maximization assumption will generally be able to find, if necessary, a "mistake" which may account for the fact that the predictions of the theory were not confirmed. In fact, the search for the "mistake" is guaranteed of success at the level of the characterization of constraints on the firm, since any behavior at all may be rationalized as profit maximizing if enough subjective or objective constraints are imposed to make the observed behavior the only "feasible" behavior.

However, there is an important issue involved in the controversy, and that question is one of research strategy. There can be no doubt that, in spite of repeated expressions of skepticism from reputable economists about the desirability of anchoring the theory of the firm to the assumption of profit maximization, the further elaboration of the implications of that assumption is almost universally acknowledged to be a legitimate objective of theoretical inquiry—with only the slightest reservations being expressed if the results are obviously without implications that can in fact<sup>1</sup> be subjected to test. On the other hand, tentative attempts to find different foundations for the theory of the firm—whether utility maximization, satisficing, or whatever—are invariably met by a query as to whether the new approach really yields the wide range of interesting conclusions that the profit maximization assumption does. Considering the comparative amounts of effort invested in investigating the implications of profit maximization as against any alternative approach, it is not surprising that the answer must be "no." However, it is precisely the desirability of this allocation of effort which is fundamentally at issue. The question is whether the large intellectual vested interest that the profession has in the assumption of profit maximization should be further increased by a continuing to allocate the major share of research effort to elaborating its implications, or whether it is time to give more encouragement to steps which might eventually permit the profession to diversify its theoretical portfolio somewhat.<sup>2</sup>

This question, of course, can only be directed to the entire social process by which the directions of economic research are determined, and therefore it is directed to no one in particular. It is an interesting and important question, nevertheless.

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1. It would obviously be undesirable to reject as empty all theoretical conclusions save those which are testable in fact. If the conclusion is testable in principle, there is always the possibility that some empirically-oriented economist will figure out a way to perform the test. Nevertheless, it seems clear that the progress of the science would be more rapid if a large proportion of the theoretical conclusions were testable in fact rather than merely in principle.

2. The current trend is toward a more diversified approach, with the research at Carnegie Institute of Technology on the "behavioral theory of the firm" being particularly worthy of mention.

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D. The Scope of the Present Study

In the context of the dispute over the assumption of profit maximization, there are several benefits that may be derived from a systematic examination of the validity and significance of the selection argument. First, there are the considerations which always justify an attempt at more rigorous formulation of an apparently plausible argument: The intuitive appeal of the argument may be deceptive, in which case the attempt to put it on firmer foundations will reveal the error, and, in addition, a clearer understanding may be achieved of the assumptions (if they exist) required to establish the proposition in question. Secondly, even if it should prove to be the case that the selection argument provides little support to any particular theory of the firm, it is nevertheless true that an assumption that in the long run firms must avoid negative profits in order to survive must, in conjunction with other assumptions not relating to the decision rules of firms, have some implications as to the types of behavior that will prove viable. It should be interesting to learn what those implications are. Finally, it may be that analysis of the requirements for viability can mediate among the contending schools of thought with respect to the theory of the firm, justifying the use of the profit maximizing model for certain classes of problems, but showing that certain details of the actual decision making processes of firms may be controlling of the outcome in other circumstances.

In Section II of this paper, certain ambiguities in existing formulations of the selection argument are discussed, and a particular unambiguous formulation of the argument is then subjected to systematic criticism. In Section III, a general formal model of economic selection processes is presented. A simple specific model, in which the only decisions taken by firms relate to output policy in the short run and to expansion policy, is analyzed in Section IV, and some of the conclusions of this analysis are then extended to a more general model. Section V consists largely of speculations about the results that might be obtained from investigation of more complicated, and less mathematically tractable, models. Some concluding remarks are made in Section VI.

II. PROFIT MAXIMIZATION AND ECONOMIC SELECTION: A CRITIQUE

A. Theories of the Firm and Theories of Entry and Exit

A discussion of the support that the selection argument affords to the traditional theory of the firm is not a discussion of facts, but of the theories used to explain and predict facts. As was explained in the previous section, some auxiliary hypothesis or other can always be introduced to protect the basic assumption of profit maximization from inconvenient facts relating to firm decision making procedures or anything else. The question to be examined now is whether this procedure is likely to be fruitful—whether the selection argument provides assurance that the protected theory will be fruitful and have a wide range of applications in which it needs no ad hoc protection.

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This question cannot be settled by appeal to any facts, since by definition the "fruitfulness" of a theory relates to its probable future successes rather than to its consistency with a limited body of existing evidence.

If this question cannot be settled by appeal to facts, how can it be settled? Perhaps it cannot be finally settled, but it can at least be clarified. If opinions on the matter must ultimately rest on intuitions rather than knowledge of reality, it is still possible to recast the question into terms which will make the relevance of the intuitions more evident. In this paper, such clarification is sought from an approach which may be likened to that of sampling theory in statistics. The individual statistician confronting his sample data wants to know what inference he should draw from it. The one strictly correct answer to this question depends on the characteristics of the population, which, however, are unknown. But some guidance as to what may constitute reasonable procedure in the face of this uncertainty can be obtained by hypothesizing more information about the population than is in fact available—e.g., that it is normally distributed with a certain mean and standard deviation. The results that would be obtained under repeated random sampling from such a population have been determined, and these results afford a standard of comparison for the actual sample results. Similarly, the discussion below hypothesizes a certain model of the real world and of the process of theorizing about it. In the context of this model one can then examine the question of what theoretical approaches would be fruitful—in particular, whether the probable fruitfulness of theories based on the assumption of profit maximization is enhanced by selection considerations. As in the case of sampling theory, the usefulness of the guidance obtained from this model is contingent upon the validity of the model, but the model itself is not subject to conclusive test.

The basic concepts in this abstract model of the problem of theorizing about the firm are as follows:

A firm is an entity with at least two permanent characteristics, (1) a particular organization form, and (2) an institutional identity—a name or identification number. The term organization form refers to a functional relationship between the state of the world (exhaustively described) and the firm's actions. This relationship may be broken down into two stages, (1) an information-acquiring stage, in which the information available to the firm is determined as a function of the state of the world, and (2) an action-taking stage in which the firm's action is determined as a function of the information available to it and of the firm's internal state.

A theory of the firm is a theory which yields refutable predictions of the behavior (actions) of particular firms or aggregates of firms; the predictions are generally conditional in the sense that they predict the behavior that will be observed given that certain states of the world obtain.<sup>1</sup> Thus a theory

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1. In the ensuing discussion, I ignore the question of whether there exists in the economic literature a theory that is a theory of the firm in the sense here defined; I simply assume that this is the case. Actually, I tend to concur in Papandreou's view that economic theorists do not produce genuine theories, i.e., theories which will pass a falsifiability test of meaning as opposed to a verifiability test. See A. G. Papandreou, Economics as a Science (New York: J. B. Lippincott Co., 1958).

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of the firm is at least a partial characterization of the organization form of firms; by indicating the behavior to be expected under particular circumstances it rules out certain possible functional connections between circumstances and behavior. A theory of entry and exit yields refutable predictions relating to the appearance and disappearance of firms; i.e., to the appearance and disappearance of institutional identities paired with particular organization forms. For example, such a theory may make conditional or unconditional statements about the organization forms of firms which come into existence, and about the states of those firms (described by balance sheets, number of employees, etc.) when created. Or it may set forth the conditions under which firms will or will not disappear—the conditions for failure or survival.<sup>1</sup>

The distinction between a theory of the firm and a theory of entry and exit is not traditionally made in economic theory. The reason is that economists have generally concerned themselves with investigating the implications of profit maximization in various contexts, and that assumption serves both as the explicit basis of the traditional theory of the firm and as an implicit theory of entry and exit. Since the assumption is made directly with respect to all firms, no question arises of distinguishing the subset of firms to which the theory of the firm relates from the set of firms in existence. However, almost any departure from the traditional style of theorizing about firm behavior immediately raises this question. A theory of decision making in large corporations, or a model of the decision processes of the manager of a department store, is a theory of the firm in the sense defined above, but it does not purport to characterize all of the firms in existence, or even to explain why firms with the particular decision processes the theory describes happen to exist in the economy. A theory of the behavior of large automobile firms need not be deduced from any universal motivational assumptions; it may be a concise explanation of certain observed regularities in the behavior of General Motors, Ford and Chrysler.

The distinction between a theory of the firm and a theory of entry and exit is particularly crucial to the understanding of the selection argument. Essentially, Alchian<sup>2</sup> suggests that instead of deducing their conclusions from a universal characterization of all firms which appear in the economy, economists should concern themselves with the implications that can be drawn from a simple characterization of the firms which do not disappear—namely, that they do not consistently make negative profits. The emphasis in the theory of entry and exit should be put on exit rather than entry. Alchian further suggests that this amendment to the theory of entry and exit restricts but does not eliminate the usefulness of the traditional theory of the firm. In particular, the traditional theory should correctly predict the change in the behavior of

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1. It is useful to consider entry and exit together because the disappearance of one or more firms (as the word "firm" is understood here) is often associated with the appearance of a new firm or firms, as in the case of mergers or complete turnovers in management.

2. Op. cit.

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aggregates of firms that will occur as a result of a change in their common economic environment. The traditional analysis should not be regarded as a tool for predicting the behavior of any individual firms, but rather for determining the types of behavior that will become more (or less) viable as a result of a given change in the environment—and thus for predicting the change in the characteristics of the set of surviving firms that a given change in the environment will produce.

Whereas Alchian stops short of asserting that the selection argument lends support to the use of the traditional theory for predicting the behavior of particular firms under given conditions,<sup>1</sup> Friedman's discussion suggests that he is willing to take this additional step. That is, Friedman appears to argue that, at least in the long run, the behavior of survivors must actually be profit maximizing behavior.<sup>2</sup> However, neither author actually offers any general statement setting the limits within which the traditional theory is considered to be adequately supported by selection considerations. The absence of such a statement reflects the existence of the ambiguities in the selection argument that are discussed below.

### B. Difficulties and Ambiguities in the Selection Argument

In the writings of the proponents of the selection argument, there is no suggestion that the support afforded to the traditional theory may depend critically on the particular types of non-maximizing behavior exhibited by firms. In fact, the existence of such a limitation is explicitly denied:

Let the apparent immediate determinant of business behavior be anything at all—habitual reaction, random chance, or whatnot. Whenever this determinant happens to lead to behavior consistent with rational and informed maximization of returns, the business will prosper and acquire resources with which to expand; whenever it does not, the business will tend to lose resources and can be kept in existence only by the addition of resources from outside.<sup>3</sup>

The objection to this sweeping statement is that the process of prospering and acquiring resources with which to expand does not occur instantaneously; some time is required for the greater profitability of firms that approach maximizing behavior to be reflected in a significantly larger relative importance of

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1. Ibid., p. 218. He also emphasized this point in his comment on the Penrose article (Alchian, Enke, Penrose, op. cit.).

2. Friedman, op. cit. This interpretation is consistent, in particular, with his use of the billiard player analogy. He is willing to predict the behavior of an expert billiard player with a theory which assumes that the player can solve the mathematical problems posed to him on the billiard table. Similarly, he says, he is willing to predict firm behavior (of firms that survive a long time) with a theory which assumes that they can actually solve the problem of profit maximization.

3. Friedman, op. cit., p. 22.

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those firms in the economy. If the immediate determinants of behavior are "habitual reaction, random chance, or whatnot," there is no reason to believe that the firms which take actions consistent with profit maximization at one time will also take actions consistent with such maximization at all subsequent times; hence, there is no obvious reason to believe that there will be any cumulative tendency for the firms which are maximizing profits at any given time to grow relative to firms which are not maximizing.

Suppose first that all firm behavior is random in the sense that decisions are made at random in each time period. There can be no tendency for the market to "select" profit maximizing firms for survival, for the simple reason that there are no consistent profit maximizers to be selected. If there is selection at all under these circumstances, it must be selection of firms with probability distributions of behavior that, in the actual cumulative process, prove to be viable. It is quite obvious that traditional economic theory is not an appropriate tool for predicting the behavior of the surviving firms, either individually or in the aggregate.

Alternatively, suppose that "habitual reaction" is the actual determinant of firm behavior. If the habitual reactions of some firms at a particular time are consistent with profit maximization, and if as a consequence these firms expand relative to other firms in the economy, this very fact will tend to alter the market price environment facing all firms. It is not clear why, in this altered environment, the same firms should continue to have the good fortune to be closer to maximizing behavior than their competitors.

There is, then, a basic difficulty in the existing statements of the selection argument, a difficulty which is rooted in the fact that the relative deviations from profit maximization of different firms may change through time. Since there has been no careful treatment of the dynamic process by which some patterns of behavior are shown to be viable and others nonviable, it has escaped notice that firms cannot in general be unambiguously ranked in terms of their closeness to maximizing behavior. Such a ranking must, in general, presume a particular state of the environment, but the environment is changed by the dynamic process itself.<sup>1</sup>

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1. It is the absence of any analysis of the dynamic process by which firms that are close to maximizing behavior drive out firms which are far from it that largely vitiates the analysis of the selection argument by G. Becker (*op. cit.*). His assumption that irrational firms choose an output level that results in nonnegative profits is purely gratuitous; the situation is further confused by his referring to the range of output levels which give nonnegative profits as an "opportunity set." (He is correctly criticized on this score by I. Kirzner ("Rejoinder," *Journal of Political Economy*, Vol. 71 (February 1963), pp. 84-85.) Irrational firms are perfectly free, in the short run, to choose output levels outside of this "opportunity set." If something prevents them from persisting in this behavior in the long run, it can only be that this course of action leads to bankruptcy. The process by which a group of irrational firms can interact in the market place so as to drive some of them out of business is crucial to the argument, and Becker provides no elucidation of this process.

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This difficulty in the writings of Alchian and Friedman is closely related to the fact that they do not distinguish between actions and organization forms and it is not clear on which the selection process is thought to operate. Alchian's treatment seems to emphasize selection of actions rather than organization forms, and this interpretation is consistent with the emphasis he places on the meaninglessness of profit maximization as a guide to behavior when choices are made under uncertainty. In an example chosen to illustrate the selection mechanism in its purest form, he postulates a situation in which every firm maintains its labor-capital ratio in the face of a rise in the real wage rate. Firms with high labor-capital ratios will be relatively worse off after the rise than before; hence their chances for survival and growth will be lower and the characteristics of the set of surviving firms shift in the direction of a lower labor-capital ratio.<sup>1</sup> Thus he appears to be thinking in terms of persistence in a particular action in the face of changing conditions. Although elements of imitative behavior and purposive behavior are introduced as supplements to the selection element in Alchian's view of economic reality, there is no extension of the selection argument itself to cover the case of systematic changes in the firm's actions as the environment changes. Friedman's position on this matter is less clear, but his use of the term "habitual reaction" might be regarded as an indication that the selection process is thought to operate on something more than individual actions. The word reaction suggests reaction to a range of different market situations.

Whatever the intention of the two authors, the distinction between actions and organization forms is crucial to the relationship between the selection argument and the traditional theory of the firm. If the selection process could be shown to operate effectively on organization forms, the support afforded to the traditional theory would be very strong indeed. Subject to the condition that there exist some firms with profit maximizing organization forms, and that the continuing creation of firms with non-maximizing organization forms be negligible, essentially the entire structure of the traditional theory would then be upheld by selection considerations. In particular, the conclusions of the standard comparative statical analyses of economic theory would be supported, and the sort of informal dynamics by which economists describe the response of firms to the appearance of profit opportunities would be relevant.

Alternatively, if the selection process is thought of as operating on

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1. Alchian, op. cit., p. 214. It is worth noting that, if some firms react perversely to a higher wage rate, Alchian's argument can fail. A rise in the wage rate may increase the minimum labor-capital ratio at which non-negative profits can be made (although it decreases the ratio at which maximum profits are made). All firms might be at this minimum value initially, and increase their labor-capital ratios sufficiently to continue to make non-negative profits after the wage rise occurs. So the characteristics of the set of surviving firms would shift in a direction opposite to that predicted by traditional theory. This illustrates the importance of setting some limits on the types of irrationality that are considered possible.

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actions, then the conclusions of the selection argument presumably relate to the actions that are taken in long run equilibrium. Even if the argument in that form were found to be valid, the fruitfulness of traditional theory would be very limited.<sup>1</sup> For example, the implications of a change in some tax rate might be incorrectly predicted by ordinary comparative static analysis, since the responses of firms to the new situations would not necessarily be profit maximizing even if their actions in the initial equilibrium were profit maximizing. Of course, a theory of entry and exit might be advanced which would predict that new firms would appear which would take the appropriate actions under the new conditions. That theory is not itself supported by the selection argument, and in any case the adjustment process envisaged is drastically different from that contemplated in traditional theory.

In brief, the existing formulations of the selection argument lack an explicit analysis of the dynamic process by which viability is tested, and the distinction between actions and organization forms is not clearly made. As a result of these deficiencies, the extent of the support afforded to the traditional theory of the firm is left uncertain.

C. Selection of Organization Forms: Some Necessary Conditions

The remainder of this section consists of an informal examination of some of the assumptions required to establish a particular version of the selection argument, a version that is sufficiently closely specified to be free of the ambiguities noted above. The argument is as follows: Consider a world of perfect and costless information in which firms have given production functions and can instantaneously make the usual short run adjustments to market conditions. Suppose, for simplicity, that all firms neglect any influence that their own purchases and sales may have on market prices; i.e., that all behave competitively. Assume that entry and exit are governed by the following stip-

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1. As Professor Simon has observed, much of the interest in the "behavioral theory of the firm" and other attempts to provide a more "realistic" theory of firm behavior lies precisely in the need to predict behavior in situations other than those of equilibrium in a static environment. He draws an analogy with the problem of theorizing about the position of a liquid in a bowl of irregular shape: If the bowl (the environment) is held steady, relatively little has to be known about the liquid to predict its behavior in equilibrium. But if the bowl is continuously shaken, or if it is desired to describe the path to equilibrium, much more knowledge of the liquid (i.e., its viscosity) is required. He takes the analogy further by suggesting that even prediction of the equilibrium position of the liquid requires considerable knowledge of its behavior if it is subject to forces other than gravity (multiple motivations). It may be taken still further by noting that the bowl may not be entirely rigid and its shape may therefore be interdependent with the character of the liquid—the actions of one firm help to shape the environment of others. See H. A. Simon, "Theories of Decision Making in Economics," American Economic Review, Vol. 49 (June 1959), pp. 255-56.

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ulations: At an initial time  $t_0$  there are many firms in the economy, of which some large number have profit maximizing organization forms in the sense that in every market situation they make the short run response that a profit maximizing competitive firm of traditional theory would make, while some other firms have organization forms which are not profit maximizing in this sense. Any firms that are created after time  $t_0$  have profit maximizing organization forms. For each firm there is a finite limit on the cumulative loss that it can incur without going out of business and permanently disappearing from the economy. The conclusion to be established is that, as time passes, the firms with profit maximizing organization forms will account for a share of the transactions in every market that approaches one in the limit; consequently, the error in the predictions of traditional economic theory with respect to the short run market behavior of firms in the aggregate will become arbitrarily small.

The situation postulated is one in which short run profit maximization is meaningful; it has been assumed that some firms actually are profit maximizers, that firms adhere to particular organization forms rather than behaving randomly, and that there is no disruptive entry of non-maximizers into the picture. Each of these assumptions is needed if the conclusion is to hold—but several other assumptions of economic interest are needed as well.

For example, suppose that several firms, including some maximizers and some non-maximizers, have identical production functions but those production functions are not characterized by constant returns to scale. If there are increasing returns to scale, it could happen that a non-maximizer has an initial scale advantage over all the maximizers. Provided his departure from maximization is not too severe, the scale advantage may more than compensate for it. If the greater profitability of the non-maximizer then induces a higher growth rate, the scale advantage of the non-maximizer will become still larger, and none of the assumptions made thus far provide any reason to think that the maximizers will ever catch up. Alternatively, suppose that returns to scale are diminishing. Then the maximizer will run into less favorable production conditions as it expands relative to non-maximizers, and at some point the difference in returns to scale may compensate for the difference in short run decision making skill. In this case, apparently, the possibility arises that maximizers and non-maximizers may coexist indefinitely simply because the maximizers cannot expand enough to put lethal market pressure<sup>1</sup> on the non-maximizers.<sup>2</sup>

Maximizers and non-maximizers may also coexist if they produce different products, or if they produce identical products, but the non-maxi-

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1. By "market pressure" I mean the tendency of one firm (or group of firms) to drive down the product prices and/or drive up the factor prices facing another firm (or group of firms).

2. However, if maximizers could create independent subsidiaries which were also maximizers, diminishing returns to scale would not limit the market pressure on non-maximizers.

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mizers have some technologically-based cost advantage. In the former case, a non-maximizer facing a downward-sloping demand curve may be held to a small scale by competition from maximizers producing less-than-perfect substitutes for its product, but will not necessarily be eliminated from the economy. In the latter case, the non-maximizer might eliminate its maximizing competitors from the economy, if there were constant or increasing returns to scale. Or it might reach an equilibrium sharing of the market with them.

Thus it appears that the conclusion of the argument stated above is generally valid only if returns to scale are constant and all non-maximizers suffer competition from maximizers producing identical products under cost conditions that are at least as favorable.

Another necessary condition is that differential profit-ability must lead to differential growth rates of maximizers relative to non-maximizers. That is, the maximizers must not be content merely to pay out their extra profits in higher dividends while remaining at the same scale, nor can they insist on some "fair rate of return" from investment in expanded facilities, if that rate is higher than the normal rate. For if the maximizers adhered to such policies, the non-maximizers would not necessarily come under sufficient market pressure to put them out of business. The assumption that the maximizers follow the proper expansion policy is obviously independent of the assumptions with respect to short run profit maximization. It is not unknown for the owners of highly profitable firms to show no interest in expansion.

Still further assumptions must be introduced to assure that a combination of financial strength in the non-maximizers and special initial conditions does not lead to an early disappearance of the maximizers from the economy. Suppose that a number of maximizers and non-maximizers produce a particular product and have identical constant returns production functions. If the total scale of all the firms taken together is sufficiently large, market price may be so low for some period of time that none of the firms make profits. If the non-maximizers can afford to take very large losses without going out of business, while the maximizers cannot, the result may be that the maximizers disappear before price rises to the point where they would break even. A somewhat similar difficulty would arise if the assumption of competitive behavior were dropped; non-maximizers might engage in a policy of price war, deliberately driving the maximizers out of business.

Finally, nothing in the assumptions identified thus far guarantees that those market situations in which the non-maximizers depart from profit maximization actually occur,<sup>1</sup> or occur for a sufficiently long period to result in the demise of the non-maximizers. To see this problem in its clearest form, suppose that in the absence of the non-maximizers the economy would reach a certain competitive equilibrium position. Assume further that, faced with the particular set of prices associated with this equilibrium, the non-maximizers happen to take profit maximizing actions. We can then imagine that the initial

1. Note that a firm is not a profit maximizer according to the definition given above if in some market situations it does not maximize profits. A non-maximizer may maximize profits in some, but not all, market situations.

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conditions might place the economy in this competitive equilibrium, with some of the non-maximizers taking the places of maximizers and taking the identical actions. Since the economy will not depart from this equilibrium, no behavior that is not profit maximizing will be observed. Although traditional economic theory "explains" the characteristics of the equilibrium, it will not correctly predict the results of some parametric change in such an economy; a parametric change may displace the equilibrium to a position where the non-maximizers do depart from maximizing behavior. Under less special assumptions, the circumstances may occur in which the non-maximizers actually do not maximize, but these circumstances may be transitory and the non-maximizers survive nevertheless.

The assumptions required to establish some version of the argument other than that set forth might not be as stringent. In an alternative version, the conclusions might relate only to the actions taken in the ultimate equilibrium of the system, or the maximizers might be held to dominate the economy in some less stringent sense than that postulated above. It is clear, nevertheless, that something more than a wave of the hand is needed to establish the scope and degree of the support that selection considerations afford to traditional theory. The problem is complex enough to make formal, rigorous analysis a virtual necessity if crucial assumptions are not to remain implicit.

### III. A GENERAL FRAMEWORK

#### A. Basic Concepts

The discussion in the previous section points to the need for an explicit formal framework within which one may investigate the general question of the constraints on firm behavior imposed by a requirement for long term survival. A fully general framework might describe the dynamic processes of growth, decline, and interaction of firms in terms of mixed systems of difference and differential equations; it might admit the possibility of random elements in firm decision making and in the exogenous variables influencing the economy; it would certainly provide some formal representation of the matters treated by a theory of entry and exit—the conditions under which firms are created or disappear, the processes by which organization forms are determined, and so forth. In the interests of simplicity, the framework presented below is quite special by comparison with such a general model. It is, nevertheless, so general that in the absence of additional assumptions it implies very little in the way of interesting results. Some indications of the directions in which the model may be further specialized are given in subsection C, and Section IV treats some specific models.

The following notational principles are adhered to: Capital letters ( $A$ ,  $X$ ,  $W$ ,  $F$ ) denote sets; corresponding small letters ( $a$ ,  $x$ ,  $w$ ,  $f$ ) refer to elements of sets. Functions are represented by small Greek letters ( $\alpha$ ,  $\eta$ ,  $\phi$ ). When a function is written without its argument, it is the function itself (i.e., the func-

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tional form) which is under consideration, not the value of the function. The subscript  $j$  on a set or an element of a set indicates that that set or element is associated with firm  $j$ . Some of the sets considered are sets of possible states of an entity; in this case a small letter subscripted with the letter  $t$  denotes the state of that entity occurring at time  $t$ . The notation  $(X, Y)$  is used for the Cartesian product of the set  $X$  and the set  $Y$ , i.e., for the set of all pairs  $(x, y)$ ,  $x \in X$ ,  $y \in Y$ .

At each of a sequence of discrete times  $t = 0, 1, \dots$ , a state of the world  $x_t$  occurs, where  $x_t$  is an element of a set  $X$  of possible states of the world. The state of the world is partially described by describing the states of the  $m$  firms; this is assumed to be accomplished by a vector of  $p$  real valued firm state variables. Examples of firm state variables might be plant and equipment owned, the entries in the firm's balance sheet, its records of past decisions made, and so forth. Denote the vector of firm  $j$ 's state variables by  $f_{jt}$ , ( $j = 1, \dots, m$ ), and the set of possible state vectors by  $F_j$ . The remainder of the job of describing the state of the world is done by a vector of real valued external variables. The list of external variables includes the prices in all markets in which any of the firms deal; it may also include such things as tax rates and the state of the weather. Denote the  $n$ -vector of external variables by  $w_t$ . Then

$$(1) \quad x_t = (f_{1t}, \dots, f_{mt}, w_t) = (f_t, w_t)$$

is a vector in  $n + mp$  dimensional real space, and  $X$  is a set of such vectors.

The decision processes of the  $m$  firms are characterized in much the same way as in the economic theory of teams, developed by J. Marschak and R. Radner.<sup>1</sup> The first stage in the decision process of a firm is an information gathering stage; firm  $j$  obtains at time  $t$  some information  $y_{jt}$  about the state of the world, where  $y_{jt}$  is an element of a set  $Y_j$  of possible outcomes of the information gathering activities of firm  $j$ . The message  $y_{jt}$  is a function  $\eta_j$  of the state of the world at time  $t$ :

$$(2) \quad y_{jt} = \eta_j(x_t) \quad j = 1, \dots, m$$

The function  $\eta_j$  is called the information structure of firm  $j$ . The second stage in the decision process is the choice of an action  $a_{jt}$  from the set  $A_j$  of possible actions of firm  $j$ . The choice of an action is constrained, however, by the firm's state. The ordered pair  $(a_{jt}, f_{jt})$  must lie in a certain relation

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1. See J. Marschak, *op. cit.* Among the earlier articles in this field are J. Marschak, "Elements for a Theory of Teams," *Management Science*, Vol. 1 (January 1955), pp. 127-137; and R. Radner, "The Linear Team: An Example of Linear Programming Under Uncertainty," in *Proceedings of the 2nd Symposium in Linear Programming* (1955), pp. 381-396.

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$R_j$  on  $(A_j, F_j)$ .<sup>1</sup> The action taken by a firm  $j$  depends both on its state and on the information available to it, in a manner described by the rule of action,  $\alpha_j$ :

$$(3) \quad a_{jt} = \alpha_j (y_{jt}, f_{jt})$$

The ordered pair  $(\alpha_j, \eta_j)$  is called the organization form of firm  $j$ , and is denoted by  $\phi_j$ . The set of possible organization forms for firm  $j$  is  $\mathcal{Q}_j$ . The ordered set of possible organization forms for the  $m$  firms is  $\mathcal{Q} = (\mathcal{Q}_1, \dots, \mathcal{Q}_m)$ .

The state of the world changes through time in a manner that depends in part on the actions of firms. It is convenient, for present purposes, to treat this dynamic process as a first order difference equation:

$$(4) \quad x_{t+1} = \psi (x_t, a_t, t)$$

where, of course,  $a_t = (a_{1t}, \dots, a_{mt})$  is the vector of actions taken by the  $m$  firms.<sup>2</sup> Time appears as an argument of the function  $\psi$  because it is interesting, in some specific models, to examine the implications of changes through time in such things as consumer preferences and the actions of government. These influences are subsumed, otherwise, in the form of the function  $\psi$ .

The vector function  $\psi$  is assumed to have the following special properties. First, external variables are not influenced by the states of firms except insofar as the latter influence the actions of firms:

$$(5) \quad \begin{aligned} x_{t+1} &= \psi_w (w_t, a_t, t) \\ f_{t+1} &= \psi_f (x_t, a_t, t) \end{aligned}$$

Secondly, for every firm  $j$  there is a nonempty subset  $D_j$  of the set of possible values of its vector of state variables such that when  $f_{jt} \in D_j$  firm  $j$  is "out of business." The sets  $D_j$  are related to the function  $\psi_f$ ; whenever  $f_{jt} \in D_j$  the function  $\psi_f$  yields a vector  $f_{j,t+1} \in D_j$ . That is, once a firm is "out of business" it is "out of business" permanently. Furthermore, all of the possible organization forms for the firm  $j$  have the property that  $f_{jt} \in D_j$  implies  $\alpha_j (y_{jt}, f_{jt}) = \bar{a}_j$ , where  $\bar{a}_j$  is a constant "null" action of firm  $j$ .

The actions of all firms depend, by way of their organization forms, on the state of the world. Therefore, once the organization forms of all firms and an initial state of the world  $x_0$  are specified, the equations (5) determine the changes in the state of the world through time.

1. The set  $A_j$  will be considered to be a set of vectors in some finite dimensional real space. The relation  $R_j$  may be defined, in particular, by the production technology open to the firm. That is, the state variables may include the firm's plant, equipment and inventories; the firm's actions may be quantities bought and sold; the relation  $R_j$  indicates how the buying and selling opportunities of the firm are limited by its plant, equipment and inventories and by the conditions of production in the firm.

2. Each of the  $a_{jt}$  may itself be a vector, as noted previously.

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### B. The General Problem of Economic Selection Theory

The theoretical issues raised by Alchian and Friedman are special cases of a more general theoretical problem: What constraints on the behavior of a firm are implied by a requirement that it be able to survive in the long run? More precisely, what combinations of organization forms of firms can coexist in the economy in the long run, given the technological and institutional conditions under which the firms interact and the definition of failure provided by given bankruptcy laws? Or, in formal terms: Given some interesting specification of the function  $\psi$ , a set  $X_0$  of possible initial conditions, and a subset  $Q'$  of the set  $Q$  of possible organization forms for the  $m$  firms, what characteristics distinguish the set of organization forms of firms that play a non-negligible role in the economy as  $t$  goes to infinity from the set of organization forms of firms that are of vanishingly small importance?

The selection argument put forward by Alchian and Friedman states that the distinguishing characteristic of a viable organization form is that it is in some sense a profit maximizing organization form. The preceding section provides examples of combinations of initial conditions and sets of possible organization forms for which this conclusion is not valid. These examples do not, however, demonstrate that the conclusion is invalid for all specifications of  $\psi$ ,  $X_0$  and  $Q'$ . Neither do they show that theorists of firm behavior have nothing to learn from a consideration of the conditions for viability in the long run. These are the questions that remain to be investigated.

### C. Further Specification of the Model: Some Difficulties

Several difficulties are immediately encountered as one attempts to investigate the general problem of economic selection theory. At the formal level, it is a simple matter to introduce additional assumptions which will eliminate the difficulties, and such assumptions are in fact introduced in the specific models treated in Section IV. However, these difficulties are not purely formal; the assumptions which eliminate them also eliminate the theoretical counterparts of phenomena which obviously exist in the real world. Therefore, it seems advisable to discuss the difficulties and some of the alternative ways in which they might be handled in the theory.

The first of the difficulties is that, given a function  $\psi$  and a particular selection  $\phi = (\phi_1, \dots, \phi_m)$  of an organization form for each firm, the survival or failure of a firm may depend on the initial conditions  $x_0$ . For example, survival may depend on the initial financial strength of the firm, as was suggested in the preceding section. Since the focus of economic selection theory is on the characterization of viable organization forms, the realization that firm survival does not depend on organization forms alone is somewhat annoying. Nevertheless, it is clear that in reality, firms which could survive in the economic environment of time  $t$  and later sometimes fail before time  $t$  arrives.<sup>1</sup>

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1. For example, consider  $t = 1939$  or  $1941$ .

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For present purposes, it is convenient to specify the dynamic process in such a way as to rule out this possibility of "transient failures". In the models of Section IV, this is accomplished by assuming that there is a limit to the percentage rate at which firms can decline in scale, and that firms are "out of business" only when they have scale zero. Thus, all firms that are "in business" initially remain so indefinitely. It is necessary to distinguish of course, the survival of a firm from the viability of an organization form. A firm survives if it does not go out of business; an organization form is viable if firms with that organization form account for a non-negligible fraction of economic activity as  $t$  becomes arbitrarily large.

More sophisticated models might admit the possibility of transient failures and the possibility of entry of new firms. In such models, the failure of all firms with a given organization form would not necessarily mean the permanent disappearance of that organization form, since it might be "re-incarnated" in newly entering firms at a later date. This would mean, however, that an organization form could be viable in the sense defined above even if all firms displaying that organization form tended to earn negative profits—there might be continuing entry of new firms with that organization form and with positive net worth. In general, the conclusions of the analysis could relate only to the shares of total activity accounted for by firms of greater or lesser life expectancy. Such conclusions might be of interest if there were a strong empirical basis for the particular modeling of the economy chosen, but in the absence of such a basis the conclusions would be hard to translate into guidance for the theorist of firm behavior.

A second difficulty that arises as the attempt is made to formulate specific models lies in the definition of the conditions under which a firm goes out of business. Recall that, under the assumptions made above, the organization form is a permanent characteristic of a firm. If the organization form associated with a particular institutional identity undergoes a change, this should be regarded as a case of one firm's going out of business and being replaced by another. At the formal level there is no difficulty in providing a definition of failure which has the essential property that a firm cannot operate at a loss indefinitely without failing. In the real world, however, changes in basic firm policies—which might be interpreted as changes in organization form—often occur when the firm still has a large positive net worth; indeed, such changes sometimes occur when the firm is making profits. It is, for example, tempting to interpret a challenge to the control of the management of a corporation as involving a demand for a change in organization form. At least, it is certain that challengers with precisely this objective would appear if a successful giant corporation were suddenly to display a systematic tendency toward negative earnings, and references to the remaining strength of the corporation's balance sheet would afford very little protection to the challenged management.

In short, the institutional processes which are the real world counterpart of the definition of failure in a selection model cannot be described merely in terms of negative net worth and the bankruptcy laws. Ideally, the formulation of the selection model should reflect this fact, but it could do so only if it

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also reflected the possibility of transient failures and of continuous entry of new firms. As was noted previously, the introduction of these complications would generally mean that the model would yield little in the way of qualitative conclusions. In any case, this step must be left to the future.

D. Organization Forms, Behavioral Assumptions, and Learning

Among the possible organization forms that might be considered in a selection model are some which implicitly attribute to decision makers a certain structuring of the decision problem they face and a certain objective. For example, the objective may be maximum profits, and the structuring of the problem may involve a subjective demand curve considered to be facing the firm, or an assumption that rival firms will hold price or quantity constant, or an assumption that next period's prices will be the same as this period's. Whenever the attempt is made to deduce behavior from assumptions to the effect that decision makers act as if they believe so-and-so and are trying to accomplish such-and-such, the problem of learning arises: If experience does not bear out the assumptions on which decision makers are presumed to act, is it reasonable to assume that they continue to act on those assumptions? This problem is, of course, familiar to economists. It has attracted particular attention in connection with certain simple models of behavior under conditions of oligopoly, such as the Cournot, Bertrand and Edgeworth solutions.<sup>1</sup>

In the context of economic selection theory, the fact that organization forms are treated as part of the exogenous data of the economic system puts the learning problem in a novel perspective. The premise of selection analysis is that actual firm responses to given market situations cannot necessarily be deduced from the assumptions on which economists have generally relied, and the objective is to determine the ultimate implications of a wider variety of behavioral assumptions. If learning phenomena are important in a certain real world situation, then a useful selection model of the situation will reflect this fact in the organization forms imputed to firms.<sup>2</sup> However, the question of whether certain learning phenomena are important is a question about decision processes, not a question about objective market conditions. It can only be answered by an investigation of what the particular firms observe, what inferences they draw from these observations, and how they translate these inferences into action.

In the models introduced below, it is assumed that all firms respond only to current price in making their output decisions. This does not rule out the possibility that some firms behave as if they faced a certain downward sloping demand curve, but it does rule out the possibility that a firm acquires

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1. See the discussion by William Fellner, op. cit., chap. ii; and, more recently, W. J. Baumel, op. cit., chap. iii.

2. However, the incorporation of any particular learning process merely pushes the learning problem back a stage. The learning process itself will be described in terms of "as if" assumptions which need not be validated by experience.

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over time additional information on (changing) elasticity of the demand curve facing it. It therefore precludes as well situations in which a firm "notices" that, with the passage of time, it has become a monopolist, and starts to act accordingly. While the reader is free to quarrel with this departure from "realism" in these very simple organization forms, it must be recognized that the quarrel is with the particular specification of the organization forms, and not with the basic assumption that organization forms are unalterable characteristics of firms. Without this basic assumption, there can be no theory of selection.<sup>1</sup>

### IV. SOME SPECIFIC MODELS

#### A. Selection of Output Determination and Expansion Rules in a Single Market

The first example of an economic selection process to be examined here is a differential equation model of a selection process operating on output determination and expansion rules for firms producing the same homogeneous product and selling in the same market. A single state variable describes the state of each firm; that variable is the firm's scale, denoted by  $f_j$  ( $j = 1, \dots, m$ ). A single external variable,  $w$ , is treated explicitly; it is the market price of the product the firms produce. Prices of current inputs and of additions to scale are assumed to be constant (the supply curves to the industry are infinitely elastic), and are not treated explicitly. Firms take two types of decisions; they choose an output rate,  $a_j$ , and a rate of change of scale,  $\dot{f}_j$ .<sup>2</sup> These decisions are based, at each point of time, on perfect information as to the value of  $w$ . Organization forms are scale free, i.e., the scale of the firm may be factored out. Thus (with a slight modification of the notation of the preceding section) the rules of action may be written as follows:

$$(1) \quad \begin{aligned} a_j &= \alpha_j(w) f_j \\ \dot{f}_j &= \psi_j(w) f_j \end{aligned}$$

At this point, only a general characterization of the set of possible rules of action is needed. The functions  $\alpha_j$  are differentiable, nonnegative, nondecreasing, and bounded. The functions  $\psi_j$  are differentiable and bounded below. Also, for each  $j$  there is a number  $w_j > 0$  (called the "zero growth

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1. One of the objections that Mrs. Penrose raised against Alchian's formulation of the selection argument can be interpreted as an objection to the absence of some such assumption. She argued that the natural selection analogy is weak because there is no economic analogue for hereditary traits, and thus nothing on which the selection process can operate. See Penrose, op. cit.

2. For notational consistency with the general model, the two actions should be labeled  $a_j^1$  and  $a_j^2$ . However, the present notation is less cumbersome.

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price" for firm  $j$ ) such that  $\psi_j(w_j) = 0$ ;  $\psi_j'(w_j) > 0$ ;  $w > w_j$  implies  $\psi_j(w) > 0$ , and  $w < w_j$  implies  $\psi_j(w) < 0$ . That is, there is a value of the market price above which firm  $j$  will expand and below which it will not. It is assumed that  $\alpha_j(w_j) > 0$ . Firm  $j$  is "out of business" if  $f_j = 0$ , but by virtue of the boundedness of  $\psi_j$  there can be no transient failures.

The rate of change of the market price is governed by excess demand:

$$(2) \quad \dot{w} = \delta(w) - \sum_j a_j$$

Here, of course,  $\delta(w)$  is the market demand curve.<sup>1</sup> The function  $\delta$  is assumed to be nonnegative and differentiable for all positive  $w$ , with a strictly negative derivative. It is also assumed that  $\delta(w) \rightarrow \infty$  as  $w \rightarrow 0$ , and that, for some  $w^0$  sufficiently large  $\delta(w^0) = 0$ .

Substituting the expression for  $a_j$  given in (1) above into equation (2), the following system of differential equations in the state of the world variables is obtained:

$$(3) \quad \begin{aligned} \dot{w} &= \delta(w) - \sum_j \alpha_j(w) f_j \\ \dot{f}_j &= \psi_j(w) f_j \quad (j = 1, \dots, m) \end{aligned}$$

The set of initial conditions to be considered is that in which all  $m + 1$  variables are given positive values, and  $w_0 < w^0$ .

A selection equilibrium for the system (3) is a set of values  $\bar{w}$ ,  $\bar{f}_j$  for  $w$  and the  $f_j$ 's such that  $\dot{w} = \dot{f}_1 = \dots = \dot{f}_m = 0$ , and  $\psi_j(\bar{w}) \leq 0$  for all  $j$ . It is the latter condition that distinguishes a selection equilibrium from any other equilibrium of the system. The possibility that some firms have  $\bar{f}_j = 0$  (thus satisfying  $f_j = 0$ ) and  $\psi_j(\bar{w}) > 0$  is ruled out. That is, in selection equilibrium it is not merely the case that the scale of each firm is constant, but price is at a level which by itself makes positive growth impossible for all firms, regardless of whether their scales are positive or zero. It may happen, of course, that  $\psi_j(\bar{w}) < 0$  in selection equilibrium for some firms; such firms must have zero scale and their organization forms are nonviable in selection equilibrium.

Given initial conditions in which all firm scales are positive, the system (3) cannot approach any equilibrium which is not a selection equilibrium. The scale of a firm that would have a positive growth rate at the price  $\bar{w}$  cannot approach zero asymptotically as  $w$  approaches  $\bar{w}$ , for the functions  $\psi_j$  are assumed to be continuous.

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1. I do not bother with multiplying the excess demand by an adjustment coefficient, since this can always be made equal to one by an appropriate normalization.

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$$(4) \quad \bar{w} = \text{Min}_j w_j$$

$$\bar{f}_j = 0 \text{ for all } j \text{ for which } w_j > \bar{w}$$

$$\bar{f}_j \text{ indeterminate for all other } j, \text{ but}$$

$$\sum_j \alpha_j(\bar{w}) \bar{f}_j = \delta(\bar{w})$$

For, at any price  $w$  above  $\bar{w}$ , some firm  $j$  has a positive  $\psi_j(w)$ ; on the other hand, at prices below  $\bar{w}$  all of the  $\psi_j(w)$  are negative, so  $f_j = 0$  implies  $f_j = 0$  for all  $j$ . This, however, is inconsistent with equilibrium in the output market, since  $w^0 > \bar{w}$ .

If it starts from initial conditions in which all firm scales are positive, the system (3) cannot approach any equilibrium which is not a selection equilibrium. The only possible equilibria which are not selection equilibria are those for which  $\psi_j(\bar{w}) > 0$  for some firm  $j$ . Equilibrium requires  $\dot{f}_j = 0$ , hence it must be that  $\bar{f} = 0$ , but a firm cannot make an asymptotic approach to zero scale as  $w$  tends to  $\bar{w}$  if it would have a positive growth rate at  $\bar{w}$ . Therefore, if the system approaches equilibrium at all, it must approach a selection equilibrium.

The conditions for viability in any possible equilibrium of the system have now been characterized. Those organization forms which have the lowest zero growth price are viable, others are not. Or, to put the matter another way, price will tend to the lowest value at which some firm's organization form still yields nonnegative growth. Firms whose organization forms result in decline at that price will approach zero scale as time goes on, leaving the firms which have the minimum zero growth price to share the market.

While having the minimum zero growth price is a necessary condition for viability of an organization form in this model, the discussion thus far does not establish that it is a sufficient condition. The transient behavior of the selection process, as well as its asymptotic behavior, could be relevant to viability if the approach to equilibrium were sufficiently slow. And if the behavior it yields in disequilibrium states of the system is relevant to the viability of an organization form, characteristics other than the zero growth price may be involved in the sufficient conditions for viability.

It happens that the question of whether there is "selection by the transient" in systems of this type is intimately connected with the question of local stability. Therefore, the first step in the analysis of selection by the transient is to linearize the system (3) around some selection equilibrium. There is a slight difficulty in carrying out this linearization, for selection equilibrium is nonunique with respect to the division of the market among viable firms, hence the system can at best be in neutral equilibrium with respect to this division. However, the conclusions of the analysis that follows hold regardless of the particular choice of positive  $\bar{f}_j$  values for viable firms, provided of course that the assigned values satisfy the condition for equilibrium in the output market, i.e.  $\sum_j \alpha_j(\bar{w}) \bar{f}_j = \delta(\bar{w})$ . The linearized system is:

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$$(5) \quad \begin{aligned} \dot{w} &= [\delta'(\bar{w}) - \sum_j \alpha'_j(\bar{w}) \bar{f}_j] (w - \bar{w}) - \sum_j \alpha_j(\bar{w}) (f_j - \bar{f}_j) \\ \dot{f}_j &= \bar{f}_j \psi'_j(\bar{w}) (w - \bar{w}) + \psi_j(\bar{w}) (f_j - \bar{f}_j) \end{aligned}$$

(for  $j = 1, \dots, m$ )

Suppose that there are  $s$  firms with organization forms that are non-viable in the equilibrium, i.e., for which  $\bar{f}_j = 0$ .<sup>1</sup> Let the firms be renumbered so that these are firms  $1, \dots, s$ . Since  $\psi_j(\bar{w}) = 0$  and  $\bar{f}_j > 0$  for firms  $s + 1$  to  $m$ , and  $\psi_j(\bar{w}) < 0$  for firms  $1$  to  $s$ , the matrix of the linear system is seen to have the following pattern of signs: (a) The first row is nonpositive, and the first element and elements  $s + 2$  through  $m + 1$  are strictly negative;<sup>2</sup> (b) Rows  $2$  through  $s + 1$  are zero except for the diagonal element, which is negative; (c) Rows  $s + 2$  through  $m + 1$  are zero except for the first element, which is positive. It is easily shown that zero is an  $(m - s - 1)$ -fold characteristic root of such a matrix, and that the remaining roots have negative real part. Furthermore, there are  $(m - s - 1)$  independent characteristic vectors associated with the characteristic root zero, and in each of them the first element is zero.<sup>3</sup>

Since the only characteristic vectors with non-zero first elements are those associated with roots with negative real part the linear system is stable with respect to  $w$ .<sup>4</sup> This means that the original system is at least locally stable with respect to  $w$ . It further means that if the quantity  $(w - \bar{w})$  approaches zero at all, it approaches essentially like  $e^{\lambda t}$ , or perhaps  $t e^{\lambda t}$ , where  $\lambda$  is algebraically the largest of the real parts of the negative characteristic roots. Finally, since integrals like  $\int_{t^*}^{\infty} e^{\lambda t} dt$  and  $\int_{t^*}^{\infty} t e^{\lambda t} dt$  are absolutely convergent when  $\lambda < 0$ , the integral  $\int_{t^*}^{\infty} (w - \bar{w}) dt$  is also absolutely convergent if  $w$  ap-

proaches the equilibrium value  $\bar{w}$  as a limit. Here,  $t^*$  may be thought of as being chosen "large enough" so that  $w$  is "close" to  $\bar{w}$  and the linear approximation is relevant. Since, however, no question of convergence arises for

1. The number of nonviable firms may be anything from 0 to  $m - 1$ .
2. Recall that  $\delta' < 0$ ,  $\alpha'_j \geq 0$ , and  $\alpha_j(w_j) > 0$ .
3. See Sidney G. Winter, Jr., "Economic "Natural Selection" and the Theory of the Firm" (unpublished doctoral dissertation, Graduate School, Yale University, 1963), Appendix.
4. For given initial conditions, the solution of the linear system for  $(w_t - \bar{w})$  consists of a linear combination of terms of the form  $z_{i1} e^{\lambda_i t}$ , where  $\lambda_i$  is a characteristic root of the matrix and  $z_{i1}$  is the first element of the associated characteristic vector (assuming that there are  $m + 1$  linearly independent characteristic vectors). Hence if the  $z_{i1}$  are nonzero only for vectors associated with characteristic roots with negative real part, the system is stable in  $w_t$ .

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the ordinary integral  $\int_0^{t^*} (w - \bar{w}) dt$ , the absolute convergence in the linear approximation establishes the absolute convergence of the improper integral  $\int_0^\infty (w - \bar{w}) dt$ .

To summarize the argument to this point: If the initial conditions are such that the system eventually reaches a small neighborhood of some selection equilibrium, then a linearized system like (5) approximates the further course of the system. The linear analysis reveals the system to be locally stable in  $w$ , and an incidental corollary of this fact is that the "discrepancy integral,"  $\int_0^\infty (w - \bar{w}) dt$ , converges.

It will now be shown that the foregoing result implies that there is no selection by the transient in this model. Consider any firm with an organization form that is viable in the equilibrium, i.e., a firm for which  $w_j = \bar{w}$ . Formally integrating the equation for this firm's growth rate in the system (3), we find:

$$(6) \quad \log f_j = \log f_{j0} + \int_0^t \psi(w) dt$$

If the integral on the right converges as  $t$  goes to infinity (specifically, if it does not go to minus infinity), then the limiting value of  $f_j$  is not zero, and all of the "transient" behavior of the system is comparable to the initial conditions in its effect on the qualitative properties of the asymptotic behavior of the system.

That this integral does in fact converge is an instance of the following theorem: Let  $x(t)$  be bounded and Riemann integrable on every finite interval, for  $t \geq 0$ . Let  $z(t) = \gamma[x(t)]$ , where  $\gamma$  is continuous on the range of  $x$ ,  $\gamma(0) = 0$ , and  $\gamma$  satisfies a Lipschitz condition at  $x = 0$ .

Theorem: If  $\int_0^\infty x(t) dt$  is absolutely convergent, then  $\int_0^\infty z(t) dt$  is likewise ab-

solutely convergent. Proof: The integrability and boundedness of  $x$  on every finite interval, together with the continuity of  $\gamma$ , imply the integrability of  $z$  on every finite interval. The Lipschitz condition asserts that there exists an  $M > 0$  and a neighborhood of  $x = 0$  such that whenever  $x$  is in this neighborhood, we have

$$(7) \quad |\gamma(x) - \gamma(0)| < M |x - 0|$$

i.e.,

$$(8) \quad |\gamma(x)| < M |x|$$

For some  $t^*$ ,  $x(t)$  will be in the appropriate neighborhood of  $x = 0$  for all  $t \geq t^*$ . A comparison test establishes the conclusion.

The application of this theorem is immediate. Make the change of variable  $x(t) = w(t) - \bar{w}$ , take  $\gamma(x) = \psi_j(x + \bar{w})$ , and note that the differentia-

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bility of  $\psi_j$  implies that the Lipschitz condition is satisfied. We conclude that there is no selection by the transient in this model, i.e.,  $w_j = \bar{w}$  is in fact a necessary and sufficient condition for viability, given initial conditions in which all firm scales are positive. Attention must now be focused on the determinants of the zero growth price. The interpretation given below is only one of several that are possible, but it is perhaps the most interesting from the point of view of the insight it affords into the relationship between selection and profit maximization.

Assume that all  $m$  firms have identical constant returns to scale production functions, and that they use identical, cost minimizing techniques to produce any given level of output with any given scale of plant. Further, assume that all firms have similar expansion policies at least to the following extent: They will expand if and only if their current gross profit per unit scale exceeds the fixed cost per unit scale; the latter comprises depreciation and a "normal return."

On these assumptions, differences in the zero growth price among firms are traceable only to differences in current profitability. The lowest price at which gross profit per unit scale equals fixed costs per unit scale is the zero growth price. Hence, the lowest possible zero growth price is that familiar quantity, the minimum of short run average total cost. (On the assumptions made, this quantity is independent of scale and is also the minimum of long run average total cost.) This will be the zero growth price of any organization form which yields the profit maximizing output level as the response to this price, and any organization form which yields a different output level at this price must necessarily have a higher zero growth price.

The conclusions of the analysis may be stated in terms of the familiar cost curve diagram of economic theory. The zero growth price of an organization form is the price at which the graph of the rule of action relating output to price intersects the average total cost curve. In Figure 1, the graphs of six such rules of action are shown in relation to the short run average total cost curve, which is assumed to be the same for all firms.<sup>1</sup> (Both the cost curve and the rules of action are "per unit scale", i.e., they are drawn for  $f_j = 1$  for all firms.) Firms 1, 2 and 3 all have the lowest possible zero growth price, since their rules of action all pass through the minimum of the ATC curve. If the system approaches an equilibrium as  $t$  goes to infinity, that equilibrium will be the ordinary competitive equilibrium. The fraction of output produced by firms like 4, 5 and 6, which do not maximize profits in that equilibrium, will approach zero.

Suppose however, that the only organization forms in the economy are those displayed by firms 4, 5 and 6. Then the selection equilibrium price will be  $w_4$ , and firms with the higher zero growth price  $w_5 = w_6$  will disappear

1. Note that marginal cost is assumed to be increasing throughout. If the curve were initially decreasing, the profit maximizing rule would have a discontinuity. The admission of discontinuities in the rules of action would complicate the argument.

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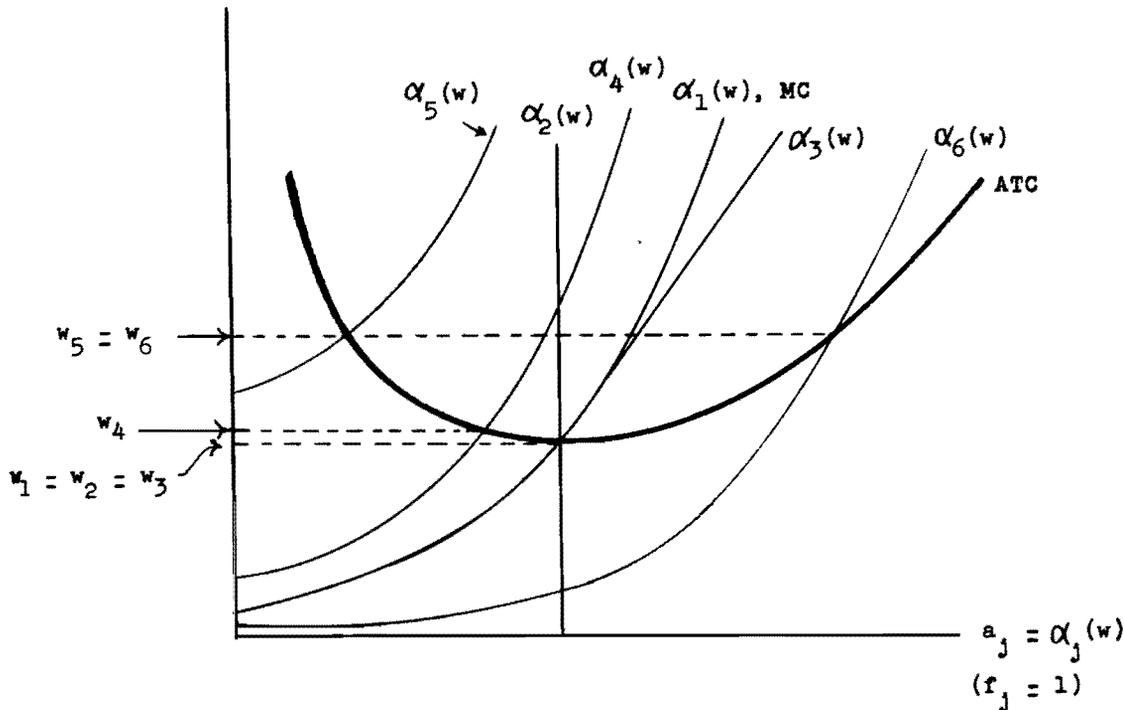


Figure 1.

from the economy. The surviving firms, with rules of action like  $\alpha_4(w)$ , will be making zero profits at a price which could yield positive profits.

The fact that there is no selection by the transient means that, if the system approaches an equilibrium, the selection process will not discriminate between the rule of action  $\alpha_1(w)$ —which yields the profit maximizing output at every price—and any other rule of action which also passes through the minimum of the cost curve. In particular, the rule  $\alpha_2(w)$ —which always calls for producing the output at which average total costs are minimized—will be as viable as any. Note also that a vague concept of “closeness” to profit maximizing behavior may be misleading. It might be argued, for example, that the rule  $\alpha_4(w)$  is “closer” to being profit maximizing than the crude “rule of thumb”,  $\alpha_2(w)$ . But  $\alpha_2(w)$  is viable and  $\alpha_4(w)$  is not, because  $\alpha_2(w)$  coincides with the profit maximizing rule at the one price level that counts.

Since the selection process provides only a weak discrimination among organization forms in this model, the use of ordinary comparative statics analysis to predict the implications of parametric changes is not justified by selection considerations. To take a simple example, suppose the system is approaching a selection equilibrium, not necessarily the ordinary competitive equilibrium. If there is a decline in the cost of a unit scale, conventional

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analysis predicts that the system will move toward a lower equilibrium price. However, selection considerations alone do not exclude the possibility that the cost of scale is a parameter of the output determination rules—e.g., lower fixed costs might lead firms to produce more, per unit scale, at every price. If the rules of action shift with the cost change, the new intersections with the new cost curve may be higher than the old equilibrium price, so the selection equilibrium price may move in the opposite direction from the competitive equilibrium price.

This simple model illustrates, therefore, one of the important objections to the selection argument that was noted in Section II. If the argument is understood as stating that only profit maximizing organization forms are viable—and it must state this if it is to afford significant support to most of existing theory—then it is necessary to ask why the variation in the state of the world should be large enough and persist long enough to discriminate between a profit maximizing organization form and one which merely coincides with it over some restricted range of situations.

It seems clear, of course, that the introduction of time as a parameter of the demand curve could increase the discrimination of the selection process. If the asymptotic behavior of the system involved a repeated fluctuation of price over a finite range, then one would expect that the viable organization forms would be those that were profit maximizing within that range (assuming the existence of some profit maximizing firms). (For example, a persistent fluctuation in the demand curve might make the rule  $\alpha_2(w)$  in Figure 1 nonviable, while  $\alpha_1(w)$  and  $\alpha_3(w)$  would still be viable.) The question would still arise: What about responses to prices outside the range of past variation? A sufficiently large parametric change would carry the system outside of that range, and the predictions of traditional theory would again be without support from the selection argument. Analogous, but more interesting, questions arise in models in which the information available to firms is imperfect and costly. For, as will be suggested in Section V, under these conditions simple "rule of thumb" decision processes may be more viable than processes which conform closely to the image of the firm in traditional theory. The selection process may discriminate against those firms that would approach profit maximizing behavior over a wide range of situations, and in favor of those which happen, by virtue of their rules of thumb, to achieve profit maximization in a restricted range of situations.

B. A Scale Free Selection Model with Several Markets

The model just presented has the great virtue of yielding a simple and understandable characterization of a viable organization form. Unfortunately, such a characterization is very difficult to achieve in models of only marginally greater complexity. To emphasize this point, I now consider a model which is basically similar to that just presented, but which involves  $n$  markets instead of one.

I retain the assumptions that organization forms are scale free and that scale (or physical capital) is a one dimensional quantity and is in infinitely elastic supply to all firms. The symbol  $w$  is now interpreted as an  $n$

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element column vector of prices of outputs and current inputs, and  $\alpha_j(w)$  is an  $n$  element column vector of outputs sold (+) and current inputs bought (-) by firm  $j$ , per unit scale. Let  $\alpha(w)$  denote the row vector  $(\alpha_1(w), \dots, \alpha_m(w))$ , or, to put it another way, the  $n \times m$  matrix of current inputs and outputs, per unit scale, for all firms. The function  $\delta(w)$  is now a column vector demand function, and some components are negative at appropriate prices. Let  $f$  be the column vector of firm scales, and  $\Psi$  be the  $m \times m$  diagonal matrix with elements  $\psi_1(w), \dots, \psi_m(w)$  on the diagonal. It is assumed that  $\psi_j(w) < 0$  for all nonnegative vectors in a neighborhood of  $w = 0$  (because of the fixed costs, which are not considered explicitly). The functions  $\psi_j$  are continuous. The dynamic system is:<sup>1</sup>

$$(9) \quad \begin{aligned} \dot{w} &= \delta(w) - \alpha(w) f \\ \dot{f} &= \Psi(w) f \end{aligned}$$

A selection equilibrium is defined, as before, as a situation in which there is no change in prices or firm scales, and no  $\psi_j$  is positive. There is, however, no simple way of characterizing the possible selection equilibria in this model. Indeed, it is not obvious that such equilibria need exist. Consider the case where there is only one firm. In the single market model, a nontrivial selection equilibrium is clearly possible provided only that the firm's zero growth price is less than  $w^0$ , for the scale of the firm can be chosen so that supply and demand are equated at the firm's zero growth price. When there are  $n$  markets to be considered, however, adjustments in a single variable, the firm's scale, will not in general suffice to establish equilibrium in all the markets simultaneously. More precisely, the fact that a firm may have a positive growth rate at the prices  $w^0$  such that  $\delta(w^0) = 0$  does not imply that there exist prices  $\bar{w}$  such that (a) the firm's growth rate is zero, and (b) for some choice of the firm's scale, the firm's input and output decisions are consistent with the market demand  $\delta(\bar{w})$ . Nor is the situation greatly improved by admitting a number of firms equal to the number of markets, in view of the nonnegativity constraints on firm scales and the absence of any guarantee of linear independence in the firms' action vectors at any particular set of prices. However, it can be shown that if certain additional conditions are imposed, a selection equilibrium must exist.<sup>2</sup>

In the single market model, the interactions among firms are strictly negative in the sense that a change in the organization form of a firm which enhances its viability (reduces the zero growth price) has if anything an adverse

1. Actually, a slight qualification to this system is needed to rule out the possibility that prices become negative. The qualification merely stipulates that the system (9) governs a price that has reached zero only if it does not call for a further decrease, and that the price will stay at zero otherwise.

2. This will be proved in a forthcoming paper, "Existence of Selection Equilibrium."

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effect on the viability of other organization forms. When there are several markets, the possibility of positive interactions arises. The viability of a firm's organization form may be enhanced when the organization forms of its suppliers are improved in certain ways, just as it might benefit from shifts in their production functions. Or a firm may depend for its existence on some particular departure from profit maximization in another firm, e.g., a practice of purchasing inputs which could be produced within the firm at a lower cost. Provided that this particular unprofitable practice is not eliminated, the firm supplying the inputs may benefit from any change which enhances the viability of its customer.

These examples illustrate the point that the viability of an organization form cannot in general be determined without reference to the entire system of organization forms in the economy. The most general question that can be asked of a particular selection process is whether certain combinations of organization forms can persist in the economy, or whether they will tend to give way to new organization forms. It is the ecological concepts of successional and climax ecosystems, rather than the simple notion of "survival of the fittest," that provide the appropriate biological analogy.

I will not attempt here to meet the challenge of providing an analysis of the several market model which treats these "ecological" features of the problem. Instead, I will treat the simplest cases where a "survival of the fittest" concept can be applied, i.e., where it is apparent that the presence of one organization form in the economy renders another nonviable. Although the remarks that follow are of very narrow applicability, they do seem to capture the element of validity in the simple observation that a firm which is "close to maximizing behavior" will tend to survive at the expense of one that is not so "close."

Assume henceforth that, given initial conditions in which all firm scales are positive, the existence and uniqueness of a solution to the differential equation system (9) is assured. Furthermore, assume that for given initial conditions the time paths of  $w$  and  $f$  are known to be bounded. I state first a relationship between the viability of an organization form and the time path of  $w(t)$ . Let  $R = \{w \mid \psi_k(w) < \psi_j(w)\}$ . Suppose that  $R$  is nonempty, and assume further that  $w(t) \in R$  for all but a finite period and that  $w(t) \in R'$ , a compact subset of  $R$ , for an infinite period. Then the organization form of firm  $k$  is nonviable. For clearly, over the compact set  $R'$  there is a positive minimum to the difference  $\psi_j(w) - \psi_k(w)$ ; hence  $\frac{\dot{f}_j}{f_j}$  exceeds  $\frac{\dot{f}_k}{f_k}$  by at least some positive quantity for an infinite period, while the growth rate of firm  $j$  is less than that of firm  $k$  for at most a finite period. Thus, to assert that  $f_k$  does not approach zero is to assert that  $f_j$  approaches infinity, contrary to the boundedness assumption. This result handles the simple cases where identical production possibilities are open to  $j$  and  $k$ , growth occurs if and only if there are positive net profits, and firm  $j$  is a profit maximizer while  $k$  departs from profit maximization in some range of situations. The other side of the coin is that any difference in the behavior of  $j$  and  $k$  in regions of the price space where  $w(t)$  spends only a finite time is irrelevant to the viability comparison.

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A sharper result can be given if it is known that the system approaches a selection equilibrium. Let  $G_j = \{w \mid \psi_j(w) \leq 0\}$ , and  $G'_k = \{w \mid \psi_k(w) < 0\}$ . If  $G_j \subset G'_k$ , then the organization form of firm  $k$  is nonviable. For let  $W$  be a compact set in the price space such that  $w(t) \in W$  for all  $t$ . (Recall that  $w(t)$  is assumed to be bounded.) The selection equilibrium price vector must lie in the compact set  $G_j \cap W$ , and over this compact set there is a maximum of  $\psi_k(w)$ . Since the maximizing  $w$  is in  $G_j$ , it is also in  $G'_k$ , and the maximum must be negative. Therefore, as the system approaches selection equilibrium,  $f_k$  must undergo negative exponential growth.

As in the simple model, therefore, we find that if the system approaches a selection equilibrium it is the ability of the organization form to yield positive growth in a wide range of price environments that determines its viability. Note, however, that the limits of this range of environments cannot be expressed as a single price, but are expressed instead as some locus in the price space. Since the particular point of the price space at which the system will settle cannot be determined without determining the solution of the whole system, it is only in the special case where the entire set  $G_j$  is included in the set  $G'_k$  that the nonviability of  $k$  can be established with ease.

If two firms have identical sets of possible organization forms, and identical expansion policies as expressed by the functions  $\psi_j$ , then it may be possible to determine the comparative viability of the two organization forms by examining the extent to which they approach profit maximization in short period production decisions. If, however, one firm is closer to maximizing behavior at one set of prices, and another at another, then viability turns on the behavior of the rest of the system. Furthermore, if the system is known to approach a selection equilibrium, then it is known that closeness to profit maximizing behavior is relevant only to the extent that the range of environments in which the firm could grow is enlarged by a closer approach to maximization.

## V. SPECULATIONS

### A. The Implications of Imperfect and Costly Information

The models of the previous section indicate that conclusions of some theoretical interest can be obtained by analytical methods when the selection process under investigation is sufficiently simple. Clearly, there is a long list of problems in economic selection theory that could be formulated as questions about the behavior of relatively simple systems of difference or differential equations. Many of these problems might well be amenable to analytical treatment. In this paper, however, the primary objective is to discover the implications of the selection mechanism for the theory of the firm. Therefore, rather than press forward with the task of subjecting simple systems to rigorous analysis, I will indicate some of the mechanisms

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that might be involved in more complicated and realistic systems, and suggest the implications of such systems for the theory of the firm.

Since so much of the discussion of the assumption of profit maximization has focused on the information and computation requirements of maximization, it is appropriate to consider first the implications for economic selection processes of imperfect and costly information. The simple single market process considered in the previous section will serve to illustrate a fundamental problem. Suppose that, instead of being free to adjust production instantaneously to perfect and costless information on the current price, firms must base their production decisions on the market price at some time prior to the time that output appears. Let the cost of a firm's information structure be a decreasing function of the difference between the time at which price is observed and the time at which the output based on that price information is forthcoming; i.e., more up-to-date information is more costly. Assume further that a firm which pays no attention to price has no information costs. Finally, let the firms have identical production functions, and expansion policies which depend in an identical way on gross profits.

If the system approaches a selection equilibrium at a sufficiently rapid rate, so that there is no selection by the transient, the following conclusion emerges: A firm with an organization form which calls for producing the output which minimizes average total costs, and ignoring price entirely, will be viable in the selection equilibrium, while the organization form of a firm which obtains price information and then chooses a profit maximizing output decision on the basis of that information will not be viable. For when the price is constant at the level of average total costs (excluding information costs), the firms produce the same output, but the firm which buys information will have lower profits and will decline. Similarly, if there are no firms which ignore price, the organization forms which yield the most out-of-date information will be the viable ones, since their information costs will be lower.

It does not pay, in terms of viability or of realized profits, to pay a price for information on unchanging aspects of the environment. It does not pay to review constantly decisions which require no review. These precepts do not merely imply that information costs must be considered in the definition of profits. For without observing the environment, or reviewing the decision, there is no way of knowing whether the environment is changing, or the decision requires review. It might be argued that a determined profit maximizer would adopt the organization form which calls for observing those things that it is profitable to observe at the times when it is profitable to observe them; the simple reply is that this choice of a profit maximizing information structure itself requires information, and it is not apparent how the aspiring profit maximizer acquires this information, or what guarantees that he does not pay an excessive price for it. An organization form which would not be viable in selection equilibrium may be viable if the asymptotic behavior of the system involves sufficient variation; the introduction of persisting variation in the demand curve in the example just given would serve to illustrate this. Thus it is not possible to know what sort of organization

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form will in fact be profit maximizing unless the dynamic behavior of the system is known, and it is clearly unreasonable to impute to firms a perfect and costless ability to predict that behavior! (In addition, of course, the behavior of the system depends on the organization forms adopted, so an attempt to determine the profit maximizing organization form involves making assumptions about the organization forms of other firms. If other firms are assumed to be engaged in the same pursuit, a conjectural variation problem emerges.)

The important conclusions to be derived from this reductio ad absurdum is that, in a world in which all information is in some degree imperfect and costly, any attempt to build a theory of behavior on the assumption that it is goal seeking (whether the goal is profits, utility, sales, or something else) must involve an as if assumption. At some level, a structuring of the problem he faces, and the possession of sufficient free information to solve it, must be imputed to the decision maker by the theorist. The a priori structure and information may or may not be objectively correct, but the theory says that the decision maker behaves as if they were objectively correct. Since the behavior predicted depends on this a priori structure and information, as well as on the assumed goal, the question arises as to what guides the theorist's choice of an as if assumption.

It is clear that economic selection considerations provide only a minimal guidance to the theorist who is determined to employ the assumption of profit maximization as his basic theoretical tool. In the example employed here, the firm that purchases information and maximizes profit on the basis of that information can be regarded as a profit maximizer behaving as if the information expenditure were optimal. The firm that sticks to the bottom of the average total cost curve and ignores price can be regarded as a profit maximizer behaving as if expenditure on information is not justified because price does not deviate from its long run value so far or so persistently as to make fine adjustments worth-while. If asked to judge which type of behavior is "closest" to profit maximizing, most economists would probably pick the former, and probably without inquiring as to the cost of the information. If so, selection considerations do not necessarily afford them any support.

Since the selection process does not necessarily discriminate in favor of modes of behavior that would ordinarily be considered "close" to profit maximizing behavior, it is worth asking whether other general characterizations of firm behavior have at least an equal claim to validation by selection considerations. In the example, the behavior of the firm that always operates at the bottom of its average total cost curve might be characterized as adherence to a simple rule of thumb, rather than rationalized as attempted profit maximization. In a somewhat different model, a monopolistic competitor which employed a "full cost" pricing rule and accepted the resulting output policy might survive at the expense of one which went through extensive and expensive calculations to find the price-output combination that equated marginal revenue and marginal cost. An expansion policy based on an uncompromising optimism as to the permanence of every increase in demand might bring the incidental benefit of unexpected economies of scale in distribution, which would place the firm in a highly secure position. It goes

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without saying that a rationalization of these types of behavior in terms of profit maximization is available, but it is certainly simpler just to describe the behavior and to note its persistence—which is the character of the statement that firms follow rules of thumb.

Another general characterization of firm behavior is summed up in the term "satisficing."<sup>1</sup> There is good reason to argue that this alternative characterization of firm behavior receives at least as much support from selection considerations as the standard characterization. The central feature of the satisficing concept is the proposition that decision makers seek "satisfactory" solutions to problems, in the sense that the acquisition of more information and the exploration of alternatives are triggered and sustained by the perception that available solutions are unsatisfactory. This proposition can be related to firm behavior at several different levels. For present purposes, it is useful to assume that a threat to the firm's survival, or the appearance of a persistent downward trend in profits or net worth, will always be regarded as an unsatisfactory situation. On this assumption, the firm may be stimulated to engage in what would ordinarily be termed profit maximizing behavior at precisely those times when its survival is endangered.

There is more to it than this, however: When the firm is doing well, it will not expend time and money on "search activity." Thus if a firm is behaving according to a routine that is actually viable, given the existing competition of other organization forms and the character of the environment, it will not be inclined to depart from the routine.<sup>2</sup> It will escape the information costs of continuously examining the possibilities in a wider range of possible behavior than it actually displays. A satisficing firm might therefore escape both the dangers of excessive rigidity in response to the changing features of the environment and the dangers of excessive attention to relatively unchanging features of the environment.

The satisficing principle is not, of course, a theory of the firm. As a basic tool for theory construction, it is certainly no more effective than the profit maximization assumption as a device for ruling out possibilities. To the extent that selection considerations lend it support, it is largely because the explicit recognition that conceivable modes of behavior remain unconsidered provides an escape from the reductio ad absurdum of information costs. At some level of analysis, all goal seeking behavior is satisficing behavior. There must be limits to the range of possibilities explored, and those limits must be arbitrary in the sense that the decision maker cannot know that they are optimal. The door is open to the question of why the limits are where they are. It is also open to the question of what particular types of satisficing behavior may be able to coexist in the economy in the long run.

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1. H. A. Simon, "A Behavioral Model of Rational Choice," *op. cit.*

2. I use the word "routine" here to mean a pattern of behavior that is followed repeatedly, but is subject to change if conditions change. If the pattern of behavior were not subject to change, the description of it would be a description of the firm's organization form.

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To sum up, the importance of information costs to the selection argument lies in the fact that, when information is costly, the types of closely calculated behavior that economists generally impute to firms may be less viable than unsophisticated behavior which simply happens to be well adapted to the conditions that actually exist. A firm that is prepared to respond to unprecedented situations in approximately the fashion that economists predict is probably a firm that is overspending on decision making in the precededent situations. Even if such a firm can hold its own, however, it clearly has no advantage in viability over less sophisticated but well adapted firms—until the unprecedented occurs. At that point, however, the response of the economy as a whole will not be accurately predicted by a theory which assumes that all firms are sophisticated.

### B. Variability in Behavior and in the Environment

The analysis thus far suggests that the selection argument affords the strongest support to the predictions of traditional theory when the situation under consideration is one to which firms have been responding for a long time. This conclusion must be qualified by reference to all of the other assumptions required to establish the conclusion that profit maximizing responses will tend to dominate in a situation that persists long enough; the assumptions that some firms actually try such a response, that firms do not have protected cost or demand situations, and that organization forms are scale free seem particularly doubtful. Nevertheless, it seems useful to consider some of the real world implications of this conclusion, implications which can be derived by analogy from the simple models presented but may be less than obvious. It is also appropriate to examine the other side of the coin—the suggestion that traditional theory derives little support from selection considerations when it is applied to novel situations—and consider its implications for economic theory.<sup>1</sup>

If the search for profit maximizing behavior is guided by selection theory, it will obviously be led to the situations which are repeatedly and persistently presented to firms. Clearly, one does not expect to find prices making an asymptotic approach to a static equilibrium, so the selection process tests something more than responses to a single market situation. One does expect, however, to find prices varying over a limited range for long periods of time, and only occasionally making marked departures from that range. It might be suggested, therefore, that business firms approach profit maximizing output choices more closely when prices are within the ordinary range of seasonal and cyclical variation than when extreme price movements occur. In situations of extremely high demand, for example, the selection theory affords no reason to expect that firms will not drastically underestimate or overesti-

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1. It should be noted that the prediction of a closer approximation to maximization in the more familiar situations can also be derived from the assumption that firms gradually learn through experience the best solution to particular problems; the two arguments reinforce each other in the cases examined here.

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mate marginal costs, or set output at the level suggested by a purely conventional concept of the capacity of the plant. In situations of extremely low demand, it does not rule out responses which seem to be based on a confusion between average total and marginal costs. Also, it is interesting to note that the selection process may operate to match production techniques to the output decision rules employed. If all firms followed full cost pricing rules, there would be a tendency for the selection process to operate in favor of production methods for which marginal costs were constant over a long range and thus to force a closer approach to maximization in a rather roundabout way.

The business cycle affords additional examples of decision problems which arise repeatedly. Selection theory might suggest that the skill of firms in determining the appropriate time for investment in plant and equipment and in inventories should have been well tested by the selection process, particularly in view of the immediacy of the threat to firm survival that a mistake in this area could represent. There is, however, a pitfall here. Although they are important and keep recurring, decisions relating to the timing of investment are made under considerable uncertainty. Success or failure in predicting market conditions over the cycle may be largely a matter of chance. Any systematic superiority of certain firms over their rivals will take a long time to manifest itself in significantly greater growth of the superior group, since the systematic difference will be swamped by the random variation. A similar comment no doubt applies to decisions on research and development spending. Although the decisions are of the utmost importance, the problems of prediction involved in making them are so large that the uncertainties may swamp any systematic superiority of one firm over another.

For examples of "unprecedented" situations firms must sometimes cope with, we may turn to the economic effects of wars, to the impact of significant innovations on non-innovating firms, or to deep depression or rapid inflation. These situations may present decision problems totally unlike those on which the selection process has been doing its work. Routine behavior that has proved viable in a relatively stable environment over a period of decades may suddenly become nonviable as a result of the appearance of substitutes or alternative sources of supply of the firm's product. War and inflation may open up dramatic profit opportunities and equally dramatic dangers of loss; hence "reckless" decision making may suddenly become more profitable and viable than the cautious behavior patterns fostered by an environment in which the thinnest margins of cost spell the difference between survival and failure. Severe depression eliminates large numbers of firms from the economy, but behavior patterns that would be viable under more normal conditions may be disproportionately represented in the casualty list. At the same time, behavior patterns that were in the process of disappearing under more normal conditions may suddenly prove viable—a firm handicapped under normal conditions by poor employee relations and a high turnover rate in its work force may do well when the labor market is weak, without changing its behavior toward its employees at all.

It is in these situations of rapid and far-reaching economic change that the fruitfulness of a theory of the firm is subjected to test. As long as

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conditions remain stable, it may be difficult to discriminate between behavior that is purposively and competently profit maximizing and behavior that happens to coincide roughly with profit maximizing behavior under those particular conditions. When novel situations arise, the opportunity presents itself to find out whether the new profit maximizing responses are made immediately or whether the responses appropriate to the past continue for some period. It is the degree and kind of inertia that firms exhibit in responding to new situations that indicates whether the behavior can best be described in terms of close calculation and attempted maximization, or whether it should be described in terms of general adherence to rules of thumb, modified when circumstances require by gradual learning, imitation, or by random search.

### C. Common Subjective Constraints

As was explicitly noted, much of the immediately preceding discussion is qualified by its dependence on an assumption that when firms are confronted by the same decision problem repeatedly over a long period of time, some firms actually adopt the profit maximizing solution to this problem. If the profit maximizing solution is attempted, selection may operate to make it dominant. I now consider the reasons why this assumption may fail, even in a society in which the desire for pecuniary gain is an important motivation.

The fundamental reason is that the larger social process of which the economy is a part may condition all decision makers to a common view of what is feasible or acceptable behavior for a firm. The profit maximizing response may be ruled out by the constraints that decision makers believe to exist or choose to recognize. For example, it may well be that bribery of judges, civil servants and the employees of other firms is indulged in to a lesser extent than, objectively speaking, the pursuit of maximum profits would dictate. Observance of ethical constraints may nevertheless be viable behavior, provided the rewards of nonobservance are not too great and the moral force of the constraints is generally recognized. Similarly, commonly held subjective constraints on the amount of interest that it is moral to charge, or on the amount of profit per unit it is moral to obtain, may make adherence to "just price" precepts a viable mode of behavior. It goes without saying that a general reluctance to exploit success by expanding one's firm and competing with one's neighbors could severely limit the effectiveness of the selection process. Finally, commonly held views of what is and is not feasible may make non-maximizing behavior viable; farmers in underdeveloped countries persist for years in using production techniques that are objectively obsolete, and it is often argued that similar behavior can be observed in industry in advanced countries.

These examples of common subjective constraints suggest well known themes in economic history. The selection process does not assure that capitalistic behavior will be typical in traditional societies. It is also true, however, that subjective constraints which do not impose objective limits on the behavior of market participants may prove to be fragile once they are challenged by some innovator—hence the familiar pattern of successful innovation by "outsiders" who do not share the society's characteristic set of subjective constraints.

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VI. CONCLUSIONS

When interpreted in the strongest possible terms, the selection argument says that all organization forms that are viable in the long run are profit maximizing organization forms. So interpreted, the argument is either meaningless or false. It is meaningless if it is meant to apply to a world of imperfect and costly information in which decision makers can never hope to obtain all the information needed to know what information should be obtained and what decisions made. In such a world the concept of profit maximization must abstract from some information costs, but there is no obviously valid choice of a level of analysis at which the abstraction should be made. Widely divergent types of behavior may be "profit maximizing" in this limited sense, depending on the choice made. The argument is false if it is meant to apply to a theoretical world of perfect information, unless every conceivable state of the world occurs not once, but repeatedly, in the selection process. Granting this implausible assumption, there remain the assumptions that organization forms are scale free, that some firms exist which are actually profit maximizers, and so on.

On a more restrictive interpretation, the argument says that the responses of surviving firms to situations that occur persistently will be profit maximizing responses. In this version, it is still qualified by the assumptions that some firms try the profit maximizing responses, that organization forms are scale free and profitable firms expand, and that continuing entry of non-maximizing firms is a negligible consideration. If these assumptions are met, the argument nevertheless does not validate the use of traditional comparative statical analysis if the effect of the parametric change is to carry the system outside of its previous range of variation. The selection process does not discriminate among organization forms with respect to responses outside that range, but the conclusions of comparative statics typically depend on those responses being profit maximizing. Also, the fact of positive information costs actually affords some reason to expect, on selection theory grounds, that responses to novel situations will not be profit maximizing.

Therefore, to the extent that selection considerations support the use of traditional economic theory, they do so only under special circumstances and for a restricted range of applications. Furthermore, the process of identifying in the real world those circumstances and applications in which traditional theory receives support is not a process that is adequately guided by traditional theory. Adequate guidance would necessarily involve, among other things, consideration of the determinants of the organization forms of newly entering firms and delineation of the circumstances under which firms make basic policy changes that amount to changes in organization form.

These weaknesses in the selection argument do not imply that theories based on the assumption of profit maximization are invalid and fruitless. They do imply that any such theory must stand on its own feet, that is, on the adequacy of its assumptions as to motivations, availability of information, and decision processes. The selection mechanism is not likely to rescue the predictions of the theory if the assumptions on these matters are

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fundamentally wrong. There may be a reason why a theory of the firm based on assumptions that do not agree with direct observation should nevertheless be expected to be fruitful, but the selection argument is not such a reason.

Finally, the limitations of the selection argument as a justification for conservatism in theoretical matters should not be taken to imply that the systematic examination of selection processes is without value. In conjunction with direct observation of business behavior, selection theory can play a useful role in limiting the area of search for more satisfactory theories of business behavior.

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