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MANAGING DISCONTINUOUS CHANGE: A SIMULATION STUDY OF ORGANIZATIONAL LEARNING AND ENTREPRENEURSHIP

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Established firms face the challenge of managing entrepreneurial strategies in order to respond effectively to major environmental changes. This paper uses a simulation methodology to explore the effectiveness of several entrepreneurial strategies in established organizations when they are faced with a fundamental restructuring of their environment. The simulated organizations are characterized by high and low levels of entrepreneurial activity and three types of entrepreneurial strategies: fixed, imitative, and adaptive. The behavior of these organizations is guided by the assumptions of an organizational learning model. The results of the simulation indicate that, given the assumptions of a learning model, there are several lessons that established organizations should consider in managing entrepreneurial strategy. First, there are important organizational implications under different levels of ambiguity. Second, lessons learned from past experience can often result in learning traps when the environment changes. Finally, conceptualizing organizations as characterized by different entrepreneurial strategies and different levels of entrepreneurship provides a theoretically useful description of differential outcomes in terms of performance, growth, and the probability of failure.

INTRODUCTION

Established firms face the challenge of managing entrepreneurial strategies in order to respond effectively to major environmental changes. Successfully choosing and implementing entrepreneurial strategies is especially difficult in established organizations because they have developed routines and structures which constrain activities. This paper uses a simulation methodology to explore the effectiveness of several entrepreneurial strategies in established organizations when they are faced with a fundamental restructuring of their environment. Entrepreneurship is conceptualized in light of a perspective which regards organizations as learning systems. The fundamental contribution of such a perspective is the recognition that organizational change can be modeled as an experiential learning process (March and Simon, 1958; Cyert and March, 1963; March and Olsen, 1976; Argyris and Schon, 1978). This paper proposes that the concepts of organizational entrepreneurship, change, and adaptation can be better understood by viewing them through the lens of a learning perspective. This learning framework is used in conceptualizing both the content and level of entrepreneurship.

Research on entrepreneurial behavior within established organizations has revolved largely around the activities of corporate venturing (MacMillan, 1986; Burgelman, 1983). This stream of research tends to focus on the factors that affect the success and failure of new product ventures, including organizational culture (Kanter, 1983; MacMillan, Block, and Subba Narasimha, 1986), top management commitment (Fast and Pratt, 1981), environmental conditions (Hambrick and MacMillan, 1985) strategy (Cooper, 1979; Biggadike, 1979), and the structure and design of new venture effort (Burgelman, 1980).
There is less attention to the organizational and environmental factors that determine when and why an established organization will pursue corporate entrepreneurship, and the degree and frequency of such entrepreneurial behavior. Further, there is no clear understanding of how entrepreneurial behavior in established organizations affects overall organizational performance.

Corporate entrepreneurship tends to be investigated with case studies (Peterson, 1967; Dunn, 1977; Burgelman, 1985) and large-scale cross-sectional empirical studies (Souder, 1981; Cooper, 1979), with most theory development consisting of case studies (MacMillan, 1986). However, there is a limit to what case studies and cross-sectional studies can tell us (MacMillan, 1986); thus, more work which investigates the complex longitudinal process of corporate entrepreneurship is needed. Research which has taken this longitudinal perspective includes Burgelman (1983), Abernathy and Utterback (1975), and Maidique and Ziger (1984). The most extensive effort so far to develop longitudinal theory of corporate entrepreneurship has been Burgelman's (1983, 1985) grounded theory studies of several ventures in a single high-technology organization. Although this work has taken us a long way toward a useful theory of corporate entrepreneurship, much more work along these lines needs to be conducted. Also, the theory development of Burgelman's studies focuses on internal organizational processes. This study makes an explicit attempt to examine factors which affect the pattern of entrepreneurial behavior across a population of organizations.

AN ECOLOGY OF STRATEGIC LEARNING

As can be seen from the brief review of studies that have examined corporate entrepreneurship, there is a need for more theory development about longitudinal patterns of entrepreneurship across organizations and the implications of different patterns for organizational performance. One reason for the lack of theory development may be the difficulty of theorizing about such complex phenomena over time. This paper argues that the development of such a theory can be enhanced through the use of a simulation methodology. The simulation developed in this paper creates a population of organizations characterized by three entrepreneurial strategies and high and low levels of entrepreneurship, which exist in the following ecology of learning. First, organizations with different entrepreneurial strategies are created and function in a stable environment for some time. Second, there is a discontinuous change in the environment; as a result, the relationship between organizational characteristics and performance is changed. Discontinuous change is conceptualized in this study as a fundamental restructuring of a formerly stable system, followed by resumption of stability within the new structure. One example might be the airline industry which had reached some level of stability in the regulated world only to be plunged into the brave new world of deregulation. Third, the relationship between organizational characteristics and performance which results from the discontinuous change remains stable. The effect of ambiguity on the learning process is also examined by comparing organizational responses under conditions of no ambiguity and high ambiguity. The effectiveness of each entrepreneurial strategy in response to this discontinuous environmental change is examined, as well as the interaction of these strategies with amount of entrepreneurial activity. Implications for performance, growth, and the probability of failure will be discussed.

In the following sections the theoretical framework for a study of the ecology of entrepreneurship, discontinuous change, and organizational performance is developed. This paper is interested specifically in the longitudinal process of how organizations learn in an environment characterized by a mix of different entrepreneurial strategies, different levels of entrepreneurship activity, and discontinuous change in the relationship between organizational characteristics and performance. This process is examined by observing organizational responses to the ecology of strategic learning described above. It is proposed that organizational change is governed by an experiential learning process. Within this learning process, entrepreneurship is conceptualized as search activity. A possible outcome of entrepreneurship is change to the core dimensions of organizational activity.
A model of experiential learning by organizations

The learning model used in the simulation depicts stylized organizations that follow rules of behavior as specified in the literature on organizational learning. An organizational learning model has three basic components. First, organizations have a target level of performance or aspiration level to which they compare their actual performance; in each period they determine whether they have performed above or below this aspiration level. The perspective that organizations set goals, or aspiration levels, and compare their actual performance to their goals, is a common theme in learning models (Cyert and March, 1963; Herriot, Levintal, and March, 1985; Lant, 1989), the psychology of decision-making (Siegel, 1957; Payne, Laughhunn, and Crum, 1980; Kahneman and Tversky, 1979), and models of organizational effectiveness (Cameron and Whetten, 1981).

Second, performance above or below aspiration level affects the likelihood of observable organizational change because performance relative to aspiration levels defines the organization's perceptions of success and failure (Cyert and March, 1963). Change in behavior is more likely when performance is below aspiration level, or perceived as failure. This is a typical outcome of trial-and-error learning; behavior that is associated with success tends to be repeated, while behavior that is associated with failure tends not to be repeated (Levitt and March, 1988).

Third, unlike the typical firms of neoclassical economics (Varian, 1978) which instantaneously scan large numbers of alternatives, a learning model suggests that the acquisition and processing of information about alternatives takes place in a relatively costly process of search (Cyert and March, 1963; March, 1978; Nelson and Winter, 1982). In sum, an organizational learning model suggests that the impetus for organizational change and adaptation is triggered by performance below aspiration level, and the content of change depends on the outcomes of the organizational search process.

Entrepreneurship in a learning framework

Entrepreneurial behavior in a learning framework involves search activities such as expending resources on the exploration of alternative possibilities, attempting to understand the relationship between organizational characteristics and outcomes, and determining the viability of organizational change. Thus, entrepreneurial behavior includes those activities directed toward discovering possibilities for change at organizations. Entrepreneurship can be conceived of not only as product or technological innovation; it also includes innovation in organizational structures and processes.1 Williamson (1983) suggests that the innovation of organizational characteristics is as crucial to our understanding of economic change as technical and product innovation, citing the wave of organizational innovations that have diffused throughout organizational populations since the 1840s. This view is echoed by Arrow (1969) and Chandler (1977), and expressed succinctly by Cole (1968: 61–62) who states if changes in business procedures and practices were patentable, the contributions of business change to the economic growth of the nation would be as widely recognized as the influence of mechanical innovations or the inflow of capital from abroad.

That such organizational changes occur as a result of search processes is suggested by Kirzner's (1979) work on entrepreneurship. In this work, entrepreneurial activity is conceptualized as the search for and discovery of alternative possibilities; the discovery of opportunities that have not yet been noticed. An individual 'searches for an understanding of how means combine to achieve ends. He seeks to attribute results to causes.' (Kirzner, 1979: 164).2 This conception of entrepreneurship suggests that such discovery occurs in a world of uncertainty; it requires a determination of some possible ends and means, an allocation of attention to discover these, and the good luck to be in the right place at the right time in order to exploit opportunities that present themselves. Learning also deals with the discovery of discrepancies (Lant, 1989) and new ways of doing things (Lant and Mezias, 1989). Thus, learning models should be appropriate for the study of organizational entrepreneurship.

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1 The idea that entrepreneurship is a dimension upon which organizations can be classified has also been suggested by Minzberg (1973).
2 The importance of search in the entrepreneurial process has also been highlighted by Muzyka (1988).
While Kirzner's (1979) conception of entrepreneurship provides a framework for applying learning models to the process of entrepreneurship, the Schumpeterian model of entrepreneurship provides a framework for classifying the three search strategies examined in this paper. Using his conceptualization, this paper categorizes search strategies by both their innovativeness and consequences for growth and survival of the firm. This categorization is represented in Table 1; the underlying rationale is developed more fully below. Schumpeter's (1950: 72) conceptualization of entrepreneurship is based on the notion of innovation, where new combinations of productive activity are created: 'the function of entrepreneurship is to reform or revolutionize the pattern of production.' In this paper organizational forms are considered part of the pattern of production. The three search strategies vary in their degree of innovativeness, or their potential for recognizing new combinations. The key result of entrepreneurship in Schumpeter's conceptualization is economic development, or value added to current conditions. The success of each of the search strategies in adding value or wealth for the organization is the focus of the simulation. The effect of each strategy on organizational performance and resources is examined.

Three major theoretical perspectives in the organization theory literature are used to derive the three search strategies:

1. A selection perspective emphasizes the costs and difficulties of search and change at the organizational level. This perspective highlights the liability of change (Hannan and Freeman, 1984). The liability of change argument suggests that there might be situations in which strategic managers should 'stay the course'. Thus, in a selection perspective, organizations do not search for information and do not change. Efforts are focused on maintaining system stability. Organizations with this pattern of behavior are said to follow a fixed strategy. Such a strategy is clearly not innovative, since no search activity takes place which would allow the discovery of new things.

2. An adaptive perspective argues that change is designed to improve performance (Thompson, 1967; Tushman and Romanelli, 1985). Organizations search for information that reveals the relationship between organizational characteristics and performance. Organizations with this pattern of search behavior follow an adaptive strategy, which enables the discovery and adoption of innovative forms. These new forms could be innovative from the perspective of the individual organization, or for the population as a whole. The adaptive search strategy is consistent with the notion of opportunistic entrepreneurship (Schollhammer, 1980), which entails scanning and surveillance in order to detect and exploit opportunities.

3. An institutional perspective argues that change is designed to become isomorphic with the characteristics of key firms (DiMaggio and Powell, 1983). Key firms, or industry leaders, establish legitimized characteristics. Organizations monitor the behavior of industry leaders and change in order to become more like these firms, and thus more legitimized. Organizations with this pattern of search behavior follow an imitative strategy, which enables the discovery of organizational forms which are new combinations for the individual organization. The imitative strategy is consistent with the notion of imitative entrepreneurship (Schollhammer, 1980), which consists of imitating achievements of other firms, and thereby learning from the mistakes of others.

The level of entrepreneurship in a learning model of organizational change can be conceptualized as the amount of search for information conducted by the organization. We argue that organizations can be characterized not only by their pattern of search activity, but also by how much entrepreneurial activity they conduct. This characteristic is called search potential in our
model: the effects of high and low levels of search potential are examined in the simulation.\(^3\) High-entrepreneurship organizations, e.g. those with high search potential, are more likely to search; conversely, low-entrepreneurship organizations, e.g. those with low search potential, are less likely to search. This classification is intuitively plausible given the common belief that some organizations are more likely to search beyond their current activities than others. Much of the literature that contrasts established organizations by level of entrepreneurship tends to focus on the extent of corporate venturing or the rate of new product development. This paper conceptualizes the level of entrepreneurship as an organizational predisposition or potential, and thus as an organizational characteristic.

Thus, the simulation in this paper is designed to examine the implications of three entrepreneurial strategies, two levels of entrepreneurial activity, and the interaction of entrepreneurial content with level. These implications are derived for organizations faced with a discontinuous environmental change in ambiguous and unambiguous environments. This approach to classifying patterns and level of search activity is reminiscent of several strategic typologies. For instance, organizational strategies have been categorized based on content (Porter, 1980; Miles and Snow, 1978) and patterns of decision-making (Mintzberg, 1973; Bourgeois and Brodwin, 1984; Tushman and Romanelli, 1985). Typologies tend to underestimate the multidimensionality of organizations and the degree to which organizations can exhibit different patterns of behavior at different times and in different contexts. They are useful, however, at early stages of theory development when such simplification is necessary. While we acknowledge the likelihood that organizations may change both the level and type of their entrepreneurial strategy, such complexity is beyond the scope of the current study.\(^4\)

The model of entrepreneurship developed in this paper further simplifies the actual process of entrepreneurship by excluding a variety of internal organizational processes that may be important, such as culture, top management commitment, and political conflict. The choice of simplification is made on several grounds. First, a simulation of longitudinal patterns would become too complicated to comprehend if it attempted to simulate a wide variety of internal mechanisms. Second, it is impossible to imbue a simulation with complexity of a human decision-maker. Third, our interest is in the implications of patterns of entrepreneurship at the organizational and population levels of analysis.

**SIMULATIONS AND STRATEGIC MANAGEMENT**

The longitudinal and evolutionary nature of the suggested theoretical framework makes deriving its implications quite complicated. It is difficult to explicate how the processes unfold over time in different contexts to yield various organizational outcomes. The unfolding of these processes can be observed, however, in a computer simulation. A computer simulation can take a complex set of assumptions, simulate a set of organizational processes, and represent the implications of these processes for organizational outcomes. Behavioral computer simulations, which model the procedures, processes, and decision rules used by a system (Crecine, 1969), have played an important, if limited, role in organizational theory development (Cohen and Cyert, 1965).

Before detailing the assumptions of the simulation developed here, it is important to put our choice of assumptions into the context of the approaches that have been used by other authors of behavioral simulations. Behavioral simulations vary in their use of linear versus nonlinear functions, rationality versus bounded rationality, types and number of feedback loops, and the interrelatedness of subprocesses. They range from an emphasis on the normative implications for organizations characterized by intendedly rational economic behavior (Nelson and Winter, 1982), to descriptions of boundedly rational but adaptive economic systems (Crecine, 1969; Cyert and March, 1963), to the descriptive implications of garbage can systems (Cohen, March, and Olsen, 1972). There has been a trend in the organizations literature to move toward more descriptive

\(^3\) An interesting question is how high and low levels of entrepreneurship evolve in organizations. This question is beyond the scope of the current study, but is a focus of current work by the authors.

\(^4\) The authors are currently working on a theoretical approach which incorporates change along these dimensions.
Simulations characterized by bounded rationality, interrelated subsystems, and feedback (Levinthal and March, 1981; Herriott, Levinthal, and March, 1985; Morecroft, 1985). Although the findings of all these simulations can be applied to strategic management theory, Morecroft's (1984) strategy support model is most clearly in the domain of strategic management. Morecroft (1985) demonstrated how intended or bounded rational subprocesses can yield dysfunctional outcomes at the macro system level.

This paper extends the application of computer simulations to the strategic management issues of organizational entrepreneurship and adaptation in the belief that behavioral simulations can be a useful model-building methodology for strategic management as well as economic and organizational theory. The simulation developed in this paper is characterized by bounded rationality, outcome feedback, several interrelated subprocesses, and primarily linear functions. The processes are bounded rational because search is routinized, sequential, and stochastic, and costly. The adaptation of aspiration levels and the decision to change are also randomized. These functions are locally sensible (Morecroft, 1985), but can produce unexpected results, as will be seen in the results. The simulation is characterized by feedback about performance, this feedback influences the adjustment of aspiration levels and the probability of change. Sterman (1989) has argued that behavioral simulations should include not only outcome feedback, but also feedback regarding how organizational actions influence environmental responses. Such feedback becomes more important when studying the interaction of individuals with system simulations, as in Sterman's (1989) research using a simulation of inventory distribution, Lant and Montgomery (1987) and Lant's (1989) research using the 'Markstrat' marketing strategy game (Larreche and Gatignon, 1977), and Cameron and Whetten's (1981) use of the Miles and Randolph (1979) 'Organization Game.' Action feedback becomes important in these instances because an important cognitive process on the part of subjects is the determination of the relationship between their actions and environmental responses. Although the simulated organizations in this paper do not receive action feedback in the true sense meant by Sterman (1989), through their routinized search process they do gain information about

The relationship between organizational characteristics, which they can change, and organizational performance.

Assumptions of this simulation

The 'data' generated by the simulation represent the implications for organizational performance, growth, and survival of the different entrepreneurial strategies and levels of entrepreneurship. It is important to highlight that the validity of these implications is subsumed in the validity of the assumptions built into the program. The assumptions made to operationalize the program follow from a perspective which views organizations as experiential learning systems. Specifically, assumptions are made about the specification of organizational characteristics, the relationship between organizational characteristics and organizational performance, the process of organizational search, and the determinants of organizational change. These subprocesses are interrelated in the following way. The search process influences the available alternatives from which the organization will choose. Performance determines the aspiration level, and performance relative to aspiration level determines the probability of choosing one of the alternatives found in the search process. The detailed specifications of the model are described below.

Organizational characteristics and performance

The purpose of organizational search, as conceptualized in this simulation, is to make determinations about maintaining or changing key organizational characteristics. The key assumption made in order to operationalize organizational characteristics and change is that organizations are completely characterized by four core dimensions (Hannan and Freeman, 1984; Tushman and Romanelli, 1985). Organization theorists have characterized organizational strategies and dimensions in numerous ways (Bourgeois and Brodwin, 1984; Miles and Snow, 1978; Mintzberg, 1973; Porter, 1980; Tushman

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5 It is also important to note that the computational specifications of these assumptions may also affect the validity of the results. These are discussed in considerable detail in the Appendix: a copy of the program, which was written in TURBO Pascal, is available from either of the authors.
and Romanelli, 1985). For the sake of simplicity, it is assumed that firms have only two choices along each of these dimensions; thus, there are 16 distinct firm types. The choice of particular labels for the core dimensions which determine an organization’s type, e.g., governance structure, or for the two choices allowed to organizations on each of these dimensions, e.g., multidivisional form or matrix form, would be arbitrary for the purposes of this simulation. However, the assumption that there are a finite number, here 16, of distinguishable types of organizations with different performance characteristics is crucial. This assumption is based on the argument that organizational performance is contingent on some sort of congruence between organizational characteristics and the environment (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Child, 1972). Thus, at the start of the simulation, each of the 16 firm types is assigned randomly a performance level which reflects its degree of fit with the environment. All 16 types may be ranked on this base performance; this ranking changes at the time of the discontinuous change. An example of how the 16 firm types may be represented, what their performance is in a given run of the simulation, and how the relationship between firm type and performance changes at the time of the discontinuous change is depicted in Table 2.

Search behavior

Entrepreneurial behavior is defined as the search for information about the relationship between organizational characteristics and outcomes and attempts to determine which changes to organizational characteristics are likely to result in desired changes to organizational outcomes. Thus, entrepreneurial behavior in this simulation consists of those activities directed toward examining new ways of doing things and assessing their validity relative to the status quo. The three entrepreneurial strategies used in the simulation describe three patterns of examination and assessment. The strategies are operationalized in the simulation in the following way:

1. In the fixed strategy organizations do not search or change. Relevant information is gathered at the time of founding; subsequently, assessments of the cost of search and the liability of change result in inertia.

2. In the adaptive strategy, organizations search for information about the relationship between organizational characteristics and organizational performance. That is, they attempt to determine which mix of organizational characteristics is associated with the highest performance and adopt these characteristics.

3. In the imitative strategy, organizations search for information about what characteristics are legitimated. Legitimated characteristics are assumed to be those adopted by key firms (DiMaggio and Powell, 1983) or industry leaders. Size functions as the proxy for the

<table>
<thead>
<tr>
<th>Upper panel: initial assignments in Period 1</th>
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<tbody>
<tr>
<td>Base performance of Type 1, denoted 1111, is −7</td>
</tr>
<tr>
<td>Base performance of Type 2, denoted 1110, is −9</td>
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<tr>
<td>Base performance of Type 3, denoted 1101, is 6</td>
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<tr>
<td>Base performance of Type 4, denoted 1011, is 9</td>
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<td>Base performance of Type 5, denoted 0111, is 0</td>
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<td>Base performance of Type 6, denoted 1100, is 8</td>
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<td>Base performance of Type 7, denoted 1010, is 0</td>
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<td>Base performance of Type 8, denoted 1001, is −2</td>
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<td>Base performance of Type 9, denoted 0110, is −7</td>
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<tr>
<td>Base performance of Type 10, denoted 0101, is 7</td>
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<td>Base performance of Type 11, denoted 0011, is 1</td>
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<td>Base performance of Type 12, denoted 0000, is 9</td>
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<td>Base performance of Type 13, denoted 0100, is −7</td>
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<tr>
<td>Base performance of Type 14, denoted 0010, is 10</td>
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<td>Base performance of Type 15, denoted 0001, is 9</td>
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<td>Base performance of Type 16, denoted 0000, is −7</td>
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<tr>
<th>Lower panel: assignments in Period 25: the discontinuous change</th>
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<tbody>
<tr>
<td>Base performance of Type 1, denoted 1111, is −8</td>
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<tr>
<td>Base performance of Type 2, denoted 1110, is −1</td>
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<td>Base performance of Type 3, denoted 1101, is 3</td>
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<td>Base performance of Type 4, denoted 1011, is 4</td>
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<td>Base performance of Type 5, denoted 0111, is 9</td>
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<tr>
<td>Base performance of Type 6, denoted 1100, is 3</td>
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<td>Base performance of Type 7, denoted 1010, is −8</td>
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<td>Base performance of Type 8, denoted 1001, is −6</td>
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<td>Base performance of Type 9, denoted 0110, is 4</td>
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<td>Base performance of Type 10, denoted 0101, is 2</td>
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<td>Base performance of Type 11, denoted 0011, is −3</td>
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<td>Base performance of Type 12, denoted 0000, is −1</td>
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<td>Base performance of Type 13, denoted 0100, is 9</td>
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<td>Base performance of Type 14, denoted 0010, is 6</td>
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<tr>
<td>Base performance of Type 15, denoted 0001, is −2</td>
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<tr>
<td>Base performance of Type 16, denoted 0000, is 1</td>
</tr>
</tbody>
</table>

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designation of which firm is the industry leader. Firms search for and identify the largest organization in the population, and adopt the characteristics of this industry leader.

The amount of information gathered by the organization will depend on the amount of search conducted. Search activity is greater for organizations with high levels of entrepreneurship, i.e., search potential; it also increases with the total resources of the organization.

**Ambiguity and performance**

In the real world of organizations the true relationship between firm characteristics and performance is difficult to determine because of uncertainty and ambiguity. The simulation explores the effects of this ambiguity by running both unambiguous and ambiguous conditions. In the unambiguous condition, firm performance is predicted perfectly by firm type. Further, the differences in performance between firm types, which are the basis of adaptive search, are accurate measures of the relative performance of different types. In the ambiguous condition, firm performance consists of a systematic component based on firm type, and a random component which differs for each firm in the population. Also, comparisons of different firm types now include both the actual difference and a random component which differs for each search conducted by an adaptive firm. It is assumed that the mean of the random components is zero; the level of ambiguity is measured by the variance of the distribution of these random components.

**Aspiration levels, performance, and likelihood of change**

Performance relative to the aspiration level of the organization determines the likelihood that observable organizational change will result from search. Organizations have a target level of performance or aspiration level; in each period they determine whether they have performed above or below this aspiration level (Lant, 1989). Aspiration levels are updated according to the formula estimated by Lant and Montgomery (1987). The probability that a firm will change one or more characteristics depends on the relationship between performance and aspiration level. The probability of change is higher when performance is below aspiration level than when performance exceeds aspiration level (Cyert and March, 1963). Change is assumed to be very costly (Hannan and Freeman, 1984). The exact decision rules governing change are probabilistic, and depend on whether performance is above or below aspiration level. For performance below aspiration level, the probability of change is an increasing function of the size of the discrepancy between actual performance and aspiration level. Thus, the worse a firm performs, the more likely it is to change. Although the probability of change is highest when performance is below aspiration level, there is a small probability that firms change even when performance is above aspiration level. Occasionally, as a direct result of search, firms discover opportunities too good to pass up. In these situations, the probability of change depends on serendipity in the form of a conjunction between the discovery of a good opportunity and the will to act on it even in the absence of performance below aspiration level.

**Simulating a population of organizations**

The set of assumptions described above are used to simulate a number of organizations over time. In each run of the program, a population of organizations is created and simulated over 100 periods. To initialize the simulation, 100 organizations are created; they are assigned randomly to the three search strategies, the 16 firm types, and to high and low levels of entrepreneurial activity. The base performance level of each of the 16 firm types is assigned randomly. The organizations commence experiencing their performance, setting aspiration levels, searching, and changing. A firm goes bankrupt when its resources fall to zero. That firm then is replaced by a random draw from the surviving firm types with positive performance. The population experiences a discontinuous environmental shock, or restructuring, in period 25. The simulation is run 100 times in the unambiguous condition and 100 times in the ambiguous condition.

**THEORETICAL PROPOSITIONS**

The overall thrust of the analysis is theory building; the results of the simulation should be viewed as implications of the assumptions of the
theoretical model, not as empirical results. We approach our theoretical investigation with a set of structured propositions about the effects of our key variables in different contexts for longitudinal patterns of organizational performance, resources, and death. Specifically, we examine the direct effect of the three entrepreneurial strategies and their interaction with high and low levels of entrepreneurship. These effects are explored longitudinally in both an unambiguous and an ambiguous environment during stable periods and preceding and following an environmental restructuring.

Unambiguous condition

The strategic management and entrepreneurship literatures suggest several predictions with respect to the performance, resource, and survival implications for firms with different entrepreneurial strategies. These predictions will be true especially in an unambiguous world. The strategic management literature implies that adaptive strategies designed to match organization structure with environmental contingencies (Thompson, 1967; Lawrence and Lorsch, 1967; Galbraith, 1973) would outperform both fixed and imitative strategies because search is focused on determining optimal fit with the environment. Similarly, while the imitative strategy will not outperform the adaptive strategy, we would expect it to outperform the fixed strategy. The entrepreneurship literature suggests the same ranking of strategies since innovative combinations of productive activity produce added value (Schumpeter, 1950).

Proposition 1: With respect to performance the ranking of the three search strategies will be the following: fixed ≦ imitative ≦ adaptive.

The same relations will hold for resources.

Proposition 2: With respect to resources the ranking of the three search strategies will be the following: fixed ≦ imitative ≦ adaptive.

The relations will be reversed for bankruptcies:

Proposition 3: With respect to bankruptcies the ranking of the three search strategies will be the following: adaptive ≦ imitative ≦ fixed.

Additional considerations come into play in discussing the effects of different levels of entrepreneurship. For fixed firms, which do not search or change, we offer no propositions about different levels of entrepreneurship. Since these firms neither search nor change, high and low levels of entrepreneurship do not differentiate these firms on the outcome measures. In the unambiguous condition, high entrepreneurship should have no effect on performance among adaptive firms. The environment is stable and the relationship between firm characteristics and performance is clear. As a result, high entrepreneurship firms tend to spend resources only to discover that the world is stable and that what worked in the past will work in the present.

Proposition 4: The performance of low entrepreneurship adaptive firms will equal that of high entrepreneurship adaptive firms in the unambiguous condition.

The predictions for differences in resources between high and low entrepreneurship adaptive firms are based on the scenario outlined for performance. In the clear world, the additional resources spent on search by high entrepreneurship firms do not add value to the firm. Thus, high entrepreneurship firms will tend to have lower resources than low entrepreneurship firms.

Proposition 5: The resources of high entrepreneurship adaptive firms will be less than the resources of low entrepreneurship adaptive firms. The size of this difference in resources will grow over time.

Similar reasoning applies to high and low entrepreneurship firms following the imitative search strategy:

Proposition 6: The performance of low entrepreneurship imitative firms will equal that of high entrepreneurship imitative firms in the unambiguous condition.

Proposition 7: The resources of high entrepreneurship adaptive firms will be less than the resources of low entrepreneurship adaptive firms. The size of this difference in resources will grow over time.
Proposition 8: With respect to performance the ranking of the three search strategies will be the following: fixed $\leq$ imitative $= adaptive$.

Proposition 11A: Prior to the discontinuous change, high and low entrepreneurship adaptive firms will have equal performance.

Proposition 9: With respect to resources the ranking of the three search strategies will be the following: adaptive $\leq$ imitative $\leq$ fixed.

Proposition 11B: Following the discontinuous change, the performance of high entrepreneurship adaptive firms will exceed that of low entrepreneurship adaptive firms. Over time, however, this difference will fade and the performance of high and low entrepreneurship adaptive firms will once again be equal.

Proposition 10: With respect to bankruptcies the ranking of the three search strategies will be the following: adaptive $\leq$ imitative $\leq$ fixed.

The effects of different levels of entrepreneurship require additional considerations. As in the unambiguous condition, we offer no propositions about different levels of entrepreneurship with respect to fixed firms because they do not search or change. Some dynamic considerations come into play in discussing the effects of different levels of entrepreneurship on adaptive and imitative firms. In periods prior to the discontinuous change, high entrepreneurship should have a no effect for adaptive firms. Even though the relationship between firm characteristics and performance is not clear, the environment is stable. As a result, high entrepreneurship firms tend to spend resources on search which has only two outcomes: first, the firms discover that the world is stable and that what worked in the past will work in the present; second, by searching more in an ambiguous world, these firms may be more likely to discover illusory improvements. Neither outcome is likely to improve performance.

The relations which will hold for resources are not the same as for performance. In particular, because adaptive firms receive ambiguous information when they search, they frequently make inappropriate changes. Further, since it has been assumed that this change is costly, these firms will suffer on the dimension of resources. Fixed firms are unaffected and will have larger resources than adaptive firms. Imitative firms use a search strategy, imitating the largest firm in the population, which should allow them to find good changes even in the face of ambiguity.

The strategic management literature has suggested that increased environmental scanning and vigilance (Aguilar, 1967), higher levels of entrepreneurship in this framework, will improve organizational performance. Adaptive strategies and increased search activities are especially important when there is a greater level of change in the environment (Galbraith, 1973); for example, after a fundamental restructuring of the environment. Thus, it is reasonable to predict that for some period of time after the restructuring high entrepreneurship adaptive firms would outperform their low entrepreneurship counterparts. Over time, however, this gap will disappear.

The relations for bankruptcies in the ambiguous condition are the same as those for bankruptcies in the unambiguous condition.

Ambiguous condition

The literature on organizational learning suggests that predictions with respect to performance, resources, and failure should change under conditions of ambiguity (March and Olsen, 1976). In particular, the prediction is that the performance of adaptive firms will suffer. Ambiguity is operationalized as noise in the relationship between firm characteristics and performance. Since this is precisely the information that adaptive firms use in their search process, it will no longer be true that their performance will exceed that of imitative firms. Noise makes the adaptive form of innovation more risky, while it has less effect on the imitative form of innovation. The prediction that the performance of both adaptive and imitative firms will exceed that of fixed firms still holds.
have lower resources than low entrepreneurship adaptive firms. The environment is stable, and more search offers no advantage and drains resources.

**Proposition 12A:** Prior to the discontinuous change, high entrepreneurship adaptive firms will have lower resources than low entrepreneurship adaptive firms. The size of this difference in resources will grow over time.

**Proposition 12B:** Following the discontinuous change, the gap between the resources of high entrepreneurship and low entrepreneurship adaptive firms will not grow as quickly.

The propositions concerning the effect of high and low levels of entrepreneurship among imitative firms are substantially similar to the propositions about the interaction of levels of entrepreneurship with the adaptive strategy. As with adaptive firms, in periods prior to the discontinuous change, high entrepreneurship should have a no effect on performance for imitative firms. The environment is stable and the type of the largest firm in the population remains stable. As a result, high entrepreneurship firms tend to spend resources only to discover that the world is stable and that the industry leader in the past is the industry leader in the present.

**Proposition 13A:** Prior to the discontinuous change, high and low entrepreneurship imitative firms will have equal performance.

The effect of level of entrepreneurship following the discontinuous change for imitative firms will parallel that of adaptive firms; this argument is based on the presumed importance of search during rapid environmental change (Galbraith, 1973).

**Proposition 13B:** Following the discontinuous change, the performance of high entrepreneurship imitative firms will exceed that of low entrepreneurship imitative firms. Over time this gap will disappear.

Based on the predictions for performance differences between high and low entrepreneurship imitative firms, the following two propositions are made about the resources of these firms:

**Proposition 14A:** Prior to the discontinuous change, the resources of low entrepreneurship imitative firms will exceed those of high entrepreneurship firms. The size of this difference in resources will grow over time.

**Proposition 14B:** Following the discontinuous change, the gap between the resources of high entrepreneurship and low entrepreneurship imitative firms will not grow as quickly.

**RESULTS AND DISCUSSION**

The propositions described above are examined in a series of figures comparing firms characterized by different entrepreneurial strategies and different levels of entrepreneurship. Results for the unambiguous condition are presented first; those for the ambiguous condition second. Figures comparing the means of the groups of firms using each of the different search strategies on the three outcome variables, performance, resources, and bankruptcies, are presented. Figures comparing the differences of the means of high and low entrepreneurship firms for the adaptive and imitative search strategies are presented for both performance and resource outcomes.

Results for the unambiguous condition

*The direct effect of entrepreneurial strategies*

The results for Proposition 1 are presented in Figure 1, which depicts mean performance by search strategy by time in the unambiguous

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*When differences between strategies and levels of entrepreneurship depicted in the figures are statistically significant, this is reported in the text. Significance tests are based on non-parametric statistical tests, unless indicated otherwise in the text, the statement of a significant difference implies that \( p < 0.01 \) for rejection of the hypothesis of no difference. Tables which report the full set of significance tests for every comparison depicted in the figures are not included, for the sake of brevity, but are available from authors. Thanks are due to anonymous reviewers whose comments on the first draft of this paper resulted in the use of figures as a way to clarify our results and illustrate important dynamics, and alerted us to possible problems in using parametrical tests. Closer examination of the underlying distributions suggested that the assumptions of non-parametrical tests were more appropriate for the data.*
condition. During the 24 periods following initialization of the simulation, the relationship between firm type and performance is stable. There is no significant difference in the performance of adaptive and imitative firms; both have significantly greater performance than fixed firms. The discontinuous change occurs in period 25; the performance of both fixed and imitative firms falls considerably, while adaptive firms seemingly are unaffected. Despite the fall, imitative firms still have performance which is significantly greater than that of fixed firms; however, the performance of imitative firms is now significantly less than that of adaptive firms. This significant difference between imitative and adaptive firms persists at $p < 0.01$ until period 40, and at $p < 0.05$ until period 50; beginning in period 60 the status quo prior to the discontinuous change resumes. From periods 60 through 100, as in periods prior to period 25, there is no significant difference in the performance of adaptive and imitative firms, and both have significantly higher performance than fixed firms.

The results for Proposition 2 are presented in Figure 2, which depicts mean resources by search strategy by time in the unambiguous condition.
During the 24 periods following initialization of the simulation, the environment is stable. There is no significant difference in the resources of adaptive and imitative firms; both have significantly greater resources than fixed firms. The discontinuous change occurs in period 25. Following this shock, adaptive firms are quick to discover which characteristics will result in high performance in the new environment, as depicted in Figure 1. However, given that change is costly, the resources of adaptive firms seem not to grow between periods 20 and 25. Nonetheless, the resources of adaptive firms remain significantly higher than the resources of fixed firms; this is true through period 100. In periods following the shock, the imitative search strategy is much slower to find a firm type which will perform well in the new environment, as depicted in Figure 1. In terms of resources this is temporary good news; the imitative firms are not so quick to change, and the costly changes which adaptive firms undertake almost immediately are avoided.

As a result, imitative firms are significantly larger than adaptive firms in period 25. There is no significant difference in period 30. Beginning in period 40 and through period 100, the resources of adaptive firms are significantly larger than those of imitative firms, and the gap grows over time. Despite this inability to sustain higher resources than adaptive firms, imitative firms remain significantly larger than fixed firms throughout the simulation.

The results for Proposition 3 are presented in Figure 3, which depicts mean total bankruptcies by search strategy by time in the unambiguous condition. Bankruptcies are initially quite high among fixed firms because the random assignment of firms to types works to a special disadvantage among the fixed firms. In this subpopulation being born a type with negative performance is an eventual death sentence, as neither search nor change takes place. Among imitative and adaptive firms bankruptcies have disappeared by the first period in which results are reported, period 10, and they never reappear. Once these firms have survived to period 30 they are protected by the size of their total resources and always adjust quickly enough so as to never lose their resource buffer completely. By period 20 the fixed firms born as types with negative performance have died; those which have survived now also are protected completely by the size of their total resources, and bankruptcies disappear among this subpopulation as well. However, the discontinuous change reintroduces bankruptcies among the fixed firms. Over time the number of bankruptcies among fixed firms decreases; however, the decrease is not monotonic. It bounces up and down as firms with different levels of resources, an artifact of different levels of performance before the shock, experience different levels of performance after the shock. The result is an oscillating rate of bankruptcies, which decreases over time, reaching zero in period 60, rises slightly again in periods 70 through 90, and eventually reaches zero again in period 100.

![Mean Number of Bankruptcies](image)

**Figure 3.** Mean number of bankruptcies by search strategy and time: unambiguous condition
The interaction of entrepreneurial strategies and levels of entrepreneurship

The results for Proposition 4 are presented in Figure 4, which depicts the difference in mean performance between high and low entrepreneurship adaptive firms as a function of time in the unambiguous condition. As the proposition suggests, high entrepreneurship adaptive firms do not have a mean performance significantly different from that of low entrepreneurship adaptive firms. There is a dip in the performance of high entrepreneurship adaptive firms immediately following the discontinuous change, but it is not significant.

The results for Proposition 5 are presented in Figure 5, which depicts the difference in mean resources between high and low entrepreneurship adaptive firms as a function of time in the unambiguous condition. As the proposition suggests, high entrepreneurship adaptive firms have significantly lower resources than low entrepreneurship adaptive firms. The amount by which low entrepreneurship adaptive firms are larger increases over time.

The results for Proposition 6 are presented in Figure 6, which depicts the difference in mean performance between high and low entrepreneurship imitative firms as a function of time in the unambiguous condition. As the proposition implies, high entrepreneurship imitative firms do not have a mean performance significantly different from that of low entrepreneurship imitative firms. The gap between the performance of high and low entrepreneurship imitative firms bounces around a bit following the discontinuous change, but none of the differences pictured in the figure are significant.

The results for Proposition 7 are presented in Figure 7, which depicts the difference in mean resources between high and low entrepreneurship imitative firms as a function of time in the unambiguous condition. As the proposition implies, high entrepreneurship imitative firms have significantly lower resources than low entrepreneurship imitative firms. The amount by which low entrepreneurship imitative firms are larger increases over time.

Results for the ambiguous condition

The direct effect of entrepreneurial strategies

The results for Proposition 8 are presented in Figure 8, which depicts mean performance by search strategy by time in the ambiguous condition. During the 24 periods following initialization of the simulation the relationship between firm type and performance is stable. There is no significant difference in the perform-

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For all of the difference figures and statistical tests reported in this study, the differences were computed by subtracting the outcome measures for low entrepreneurship firms from the outcome measures for high entrepreneurship firms.

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Figure 4. Performance by entrepreneurship by time: adaptive firms, unambiguous condition.
The discontinuous change occurs in period 25; one result is a small fall in performance among adaptive firms. The more notable result is a steep decline in the performance of both fixed and imitative firms; the fall in performance among imitative firms is so precipitous in period 25 that the performance of imitative and fixed firms is not significantly different. In addition, the performance of both imitative and fixed firms is now significantly less than that of adaptive firms. This significant difference in performance between adaptive and fixed firms persists until the end of the simulation. Beginning in period 30, imitative firms once again significantly outperform fixed firms. However, the significant outperformance of imitative firms by adaptive firms persists until period 50 at $p < 0.05$. By period 70 the status quo prior to the discontinuous change resumes. From periods 70 through 100, as in periods prior to period 25, there is no significant difference in the performance of adaptive and imitative firms, and both have significantly higher performance than fixed firms.

The results for Proposition 9 are presented in Figure 9, which depicts mean resources by search strategy by time in the ambiguous condition.
During the 24 periods following initialization of the simulation the environment is stable. There is no significant difference in the resources of fixed and imitative firms; both have significantly greater resources than adaptive firms. The discontinuous change occurs in period 25. In response to this shock, imitative firms begin to use information acquired through search to make changes to firm types which are more appropriate to the new order. This results in imitative firms having significantly lower resources than fixed firms starting in period 30. This difference persists at a significance level of $p < 0.05$ (one-sided test) through period 70. Beginning in period 80 and through period 100 the status quo which preceded the discontinuous change is restored: the resources of imitative and fixed firms are not significantly different. Probably the key result to be noted in this figure is the ravaging of the resources of adaptive firms which results from ambiguity. Although these firms perform better on average than fixed firms, and better than imitative firms in the periods following the discontinuous change, this higher performance does not result in growth. Most of the resources of these firms are spent making inappropriate changes suggested by search in an ambiguous world. Beginning in period 10 and continuing
through the end of the simulation in the ambiguous condition, the resources of both fixed and imitative firms are significantly larger than those of adaptive firms, and the gap grows over time.

The results for Proposition 10 are presented in Figure 10, which depicts mean bankruptcies by search strategy by time in the ambiguous condition. In the ambiguous condition the pattern of results for bankruptcies is identical to the pattern in the unambiguous condition. Bankruptcies are initially quite high among fixed firms because the random assignment of firms to types works to a special disadvantage among the fixed firms. Among imitative and adaptive firms bankruptcies have disappeared by the first period in which results are reported, and they never reappear. Once these firms have survived to period 10 they are protected by the size of their total resources, and always adjust quickly enough so as never to lose their resource buffer completely. By period 20 many of the fixed firms born as types with negative performance have died; mean bankruptcies in this subpopulation decline considerably as a result. However, in the wake of the discontinuous change, bankruptcies among the fixed firms rise once again. Over time the number of bankruptcies among fixed firms
decreases; as in the unambiguous condition, however, the decrease is not monotonic. It bounces up and down as fixed firms with different levels of resources, an artifact of different levels of performance before the shock, experience different levels of performance after the shock. The result is an oscillating rate of bankruptcies, which sometimes decreases and sometimes increases, not quite reaching zero by period 100.

The interaction of entrepreneurial strategies and levels of entrepreneurship

The results for Propositions 11A and 11B are presented in Figure 11, which depicts the difference in mean performance between high and low entrepreneurship adaptive forms as a function of time in the ambiguous condition. As Proposition 11A implies, high entrepreneurship adaptive firms do not have a mean performance significantly different from that of low entrepreneurship adaptive firms before the discontinuous change. As predicted by Proposition 11B, there is a rise in the performance of high entrepreneurship adaptive firms relative to low entrepreneurship adaptive firms immediately following the discontinuous change, in period 25; this difference is marginally significant, $p < 0.10$, in a one-sided test. However, by period 30 the gap is reversed; low entrepreneurship adaptive firms have significantly higher performance than high entrepreneurship adaptive firms at $p < 0.05$, contradicting Proposition 11B. The difference in performance between high and low entrepreneurship adaptive firms ceases to be significant in Period 40; it changes sign again before period 100, but it is not again significant.

The results for Propositions 12A and 12B are presented in Figure 12, which depicts the difference in mean resources between high and low entrepreneurship adaptive forms as a function of time in the ambiguous condition. Proposition 12A implies that, before the discontinuous change, high entrepreneurship adaptive firms have lower resources than low entrepreneurship adaptive firms. The resources of low entrepreneurship adaptive firms are significantly greater than those of high entrepreneurship adaptive firms in period 20. Proposition 12B implied that the rate of increase in this gap would slow following the discontinuous change. However, the results are considerably stronger than a mere slowing of the increase in the gap; the size of the gap actually declines in certain periods. The significant difference in resources in favor of the low entrepreneurship firms persists through period 40, when it ceases to be significant. However, in periods 50 through 80 low entrepreneurship adaptive firms are once again significantly larger than high entrepreneurship adaptive firms. Finally, in periods 90 and 100 the difference is no longer significant.

The results for Propositions 13A and 13B are presented in Figure 13, which depicts the difference in mean performance between high and low entrepreneurship imitative firms as a function of time in the ambiguous condition. As Proposition 13A implies, high entrepreneurship imitative firms do not have a mean performance significantly different from that of low entrepreneurship imitative firms prior to the discontinuous change. Proposition 13B implies that high entrepreneurship imitative firms will have performance significantly greater than that of low entrepreneurship imitative firms following the discontinuous change. The gap between the performance of high and low entrepreneurship imitative firms bounces around a bit following the discontinuous change. The first time the difference is notable is in period 30, when the performance of high entrepreneurship imitative firms is marginally greater than that of low entrepreneurship imitative firms at $p < 0.10$ for the one-sided test. The differences in performance reverse sign in periods 40 and 50, with low entrepreneurship imitative firms outperforming high entrepreneurship imitative firms, but the differences are not significant. In period 70 the signs reverse again; at this time high entrepreneurship imitative firms perform significantly better than low entrepreneurship imitative firms, $p < 0.05$ for the one-sided test. The signs reverse again in period 80, but the difference is not significant. Period 90 again offers support for Proposition 13B: high entrepreneurship imitative

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This apparent anomaly will be discussed further in the section on learning traps.
firms significantly outperform low entrepreneurship imitative firms, $p < 0.05$ for the one-sided test. In period 100, high entrepreneurship imitative firms continue to outperform low entrepreneurship imitative firms, but the difference is not significant.

The results for Propositions 14A and 14B are presented in Figure 14, which depicts the difference in mean resources between high and low entrepreneurship imitative firms as a function of time in the ambiguous condition. As Proposition 14A implies, high entrepreneurship imitative firms have lower resources than low entrepreneurship imitative firms. The amount by which low entrepreneurship imitative firms are larger is significant and increases between periods 10 and 20. Proposition 14B implies that the rate of increase in the gap between high and low entrepreneurship imitative firms on resources will decrease following the discontinuous change. This is supported by the results: the size of the excess of resources among low entrepreneurship imitative firms relative to high entrepreneurship imitative firms is stationary from periods 20 to 50. After that the excess begins increasing, as before the discontinuous change, once again.
Discussion

Further interpretation of the results offers an interesting description of the effectiveness of different entrepreneurial strategies and different levels of entrepreneurship. The implications are made even more interesting by the contrast between the same ecology of strategic learning in the no ambiguity and high ambiguity conditions.

No ambiguity condition

In the unambiguous condition the effects on performance are not too surprising for the periods prior to the environmental change. Fixed firms which do not search and change do worse than those which do. Because the relationship between firm characteristics is clear and stable, high levels of entrepreneurship help neither the imitative nor adaptive firms. Following the environmental change, both the adaptive and imitative strategies are more effective than the fixed strategy. Adaptive firms discover the correct pattern of characteristics sooner than imitative firms. The dip in the performance of the imitative firms can be explained as follows: the industry leader, i.e. the largest firm in the population, was a high-performing type prior to the environmental
change, but will tend not to be a high-performing type after the change. However, such a large firm is likely to maintain its relative size for some time after its characteristics no longer provide an optimal fit with the environment. Thus, when imitative firms search, the information they gather leads them to imitate the industry leader which became such under the old environmental configuration; performance suffers as a result. However, the size of the original industry leader eventually declines, and a firm which is a high-performance type under the new environmental configuration eventually becomes the largest firm in the population. Thus, imitative firms eventually copy the correct type of firm, which is why, in the long run, adaptive firms do not outperform imitative ones. In the long run, adaptive firms which have discovered the new high-performing types become the industry leaders, because the performance gain of changing to a high-performing type more than makes up for the cost of change.

The effects on resources in the unambiguous condition are also not surprising. As in the case of performance, both the adaptive and imitative strategies increase average resources in comparison to the fixed strategy, both before and after the environmental change. High levels of entrepreneurship are costly and do not increase performance in the unambiguous condition; as a result, high entrepreneurship firms, both imitative and adaptive, have fewer resources than their low entrepreneurship counterparts.

In the unambiguous condition, firms with either adaptive or imitative strategies have a lower number of bankruptcies than fixed firms. The environmental shock increases the number of bankruptcies but, again, the firms to go bankrupt are fixed firms. Thus, when the performance of firms is perfectly predicted by firm characteristics, as in the unambiguous condition, and the firms which search can discover this, they do pretty well in changing to firms with positive performance. Adaptive and imitative firms are equally successful in eliminating bankruptcies. The results for bankruptcies also illustrate a concept which is becoming increasingly important in models which support the notion of change at both the population and organizational levels of analysis. As Levinthal (1989: 11) summarizes the argument: ‘Organizations with a large capital stock are, however, as a practical matter, not at risk for failure in the current time period.’ To account for this he introduces the notion of the refined risk set: those organizations with resources small enough to be at risk for failure. Thus, rather than a population of organizations at general risk of failure, the analyst deals with a population where only some organizations are at risk; Miner, Amburgey, and Stearns (1987) have described the related idea of partial selection.

In terms of the results of this study, fixed firms in early periods are at risk of failure; bankruptcies among adaptive and imitative are essentially zero. The bouncing pattern of bankruptcies among the fixed firms following the discontinuous change is a reflection of the movement into the refined risk set of varying numbers of fixed firms. As discussed in the review of the results, this will be a history-dependent function of the randomly assigned performance levels. As indicated by the movement of bankruptcies among fixed firms to zero in period 20, before the discontinuous change, surviving fixed firms by this point are characterized by non-negative performance. The rate of bankruptcies after the discontinuous change will depend mainly on two factors: the first is the level of positive performance before the discontinuous change, which determines the accumulation of resources. The second is the random assignment of performance after the discontinuous change; this determines if and at what rate the capital stock accumulated before the discontinuous change becomes depleted. After period 20, only fixed firms of types which are assigned negative performance at the time of discontinuous change go bankrupt.

**High-ambiguity condition**

As the implications summarized below indicate, the effects of entrepreneurial strategies and the level of entrepreneurship are influenced by ambiguity in the relationship between organizational characteristics and performance. Some effects remain the same, however. For instance, both adaptive and imitative strategies are for the most part better than the fixed strategy in discovering what characteristics lead to better performance both before and after the environmental change. Thus, even when the relationship between performance and characteristics has a very high variance, it is better to search than not to search at all. The one exception to this is that the performance of imitative firms, which
are slower to respond appropriately to the discontinuous change, is not significantly different from the performance of fixed firms in period 25 when the discontinuous change occurs.

The results for resources in the ambiguous condition are quite different from what was found in the unambiguous condition. The primary reason for this is the effect of ambiguity on search and change; essentially, they become more expensive because they do not result in improved performance as quickly or as frequently as they did in the unambiguous environment. That is, it takes longer for firms to discover good choices of characteristics and they are more likely to make errors in the course of this discovery. This is illustrated particularly well by the impact of an adaptive strategy on average resources. Adaptive firms are too sensitive to the noise in the system and spend too much of their resources searching and changing in ways that do not result in improved performance. Imitative firms, by searching for the largest firm in the population, do better than adaptive firms. Prior to the discontinuous change there is no difference in the resources of imitative and fixed firms. Beginning in period 30, however, as imitative firms search and change, the costly expenditure of resources to do so reduces their resources significantly relative to fixed firms. This significant difference persists until period 80; at that point the higher performance of imitative firms begins to result in enough additional resources to render the resources gap between imitative and fixed firms not significant.

The effects of high and low levels of entrepreneurship among imitative and adaptive firms are considerably more complicated in the ambiguous condition. Among adaptive firms the relationship between high and low levels of entrepreneurship and performance is as follows: in the period of the discontinuous change, increased entrepreneurship improved performance for adaptive firms, as predicted by Proposition 11A; however, the effect is only marginally significant. More surprisingly, the direction of higher performance is reversed by period 30, when low entrepreneurship adaptive firms significantly outperform high entrepreneurship firms. By period 40 the difference is no longer significant; the performance differential continues to vary in value for the remainder of the simulation but the difference between high and low entrepreneurship adaptive firms is not again significant. The explanation for this result lies in the direct effect of ambiguity on the search conducted by adaptive firms. The effectiveness of the adaptive search rule is compromised severely by the introduction of ambiguity into the relationship between firm characteristics and performance.

The relationship between high and low levels of entrepreneurship among imitative firms and performance is somewhat different than for adaptive firms. Before the discontinuous change Proposition 13A is supported; there is no difference in performance between high and low entrepreneurship imitative firms. After the discontinuous change Proposition 13B is supported; the performance of high entrepreneurship imitative firms is significantly greater than that of low entrepreneurship imitative firms; however, the effect is not immediate. The difference is not significant until periods 70 and 90. The pattern of support for this proposition is punctuated because of complications in the determination of the rate at which the old industry leader is replaced following the discontinuous change. The emergence of a new leader to replace the old will be a history-dependent process governed by the stochastic assignment of performance levels before and after the discontinuous change.

The effect of entrepreneurial strategies on the numbers of bankruptcies is essentially the same in both the unambiguous and ambiguous condition. Having an adaptive or imitative strategy moves firms out of what Levinthal (1989) calls the refined risk set; the number of bankruptcies among these firms is reduced to zero by period 10. The pattern of results for the fixed firms is qualitatively the same as in the unambiguous condition. The curve mapping total bankruptcies among these firms as a function of time indicates the same relationship as in the unambiguous condition, but with a higher intercept.

CONCLUSIONS AND IMPLICATIONS

This paper has used a simulation methodology to explore the theoretical implications of the content and amount of organizational entrepreneurship in established firms facing a discontinuous environmental change. An organizational learning perspective was used to conceptualize entrepreneurship. Three entrepreneurial strate-
gies were represented by three different patterns of search behavior. The level of entrepreneurial activity was represented by different levels of search potential implying different amounts of search activity. The theory implies that both the content and amount of entrepreneurial activity will affect several measures of organizational outcomes. The results are particularly noteworthy in several respects. First, the contrast between the consequences to organizations of an environmental restructuring under conditions of no ambiguity and high ambiguity is interesting. This is especially true with respect to the recommendations for strategies aimed at affecting performance and total resource outcomes. Second, two fallacies in the form of traps in the learning process (Levitt and March, 1988) seem to be indicated by the results. Third, the longitudinal nature of the theoretical development in this study clearly indicates some specific ways in which the lessons of the past are not always good guides to the future. Finally, important trade-offs that must be considered in regarding organizations as learning systems are highlighted by these results.

Recommendations

Unambiguous condition

Two recommendations about the management of discontinuous change when the relationship between firm characteristics and performance is unambiguous are implied by the organizational learning perspective developed here. First, firms adopting either an imitative or adaptive strategy need not incur the costs of high levels of entrepreneurship. Figures 5 and 7 demonstrate that the costs of high entrepreneurship are not justified by the returns. Two important assumptions used to simplify this preliminary theoretical study need to be kept in mind when interpreting this recommendation. The first is that possibilities for change pre-exist and are limited to a set of 16 firm types. Entrepreneurship, as it has been studied here, does not result in the development of new types, but is directed at searching through the existing types to find those that might be viewed as more desirable given a firm's search strategy (cf. Leivinthal and March, 1981). This paper conceptualized entrepreneurship as a process of scanning the environment; thus, this is the type of entrepreneurship to which the recommendation applies. The second assumption is that the relationship between performance and firm type is assigned in the first period, is completely stable for 24 periods, changes completely at the time of the discontinuous change, and remains stable for the remainder of the simulation. To the extent that the relationship between firm characteristics and performance is not completely stable between periods of discontinuous change, entrepreneurship directed at scanning the environment, even in a relatively unambiguous world, might have somewhat higher value than what has been found here.

The second recommendation suggests that, with the exception of the periods immediately following the discontinuous change, the differences between an imitative and adaptive strategy are not very significant. In this simulation the assumption was made that adaptive and imitative search had identical costs. To the extent that adaptive search is more costly than imitative search, this assumption is not valid. The costs incurred in the discovery and implementation of adaptive changes may be considerably higher than those involved in imitation in some strategic decision-making contexts. To the extent that this difference is large, an imitative strategy may be preferable. Conversely, no considerations of density dependence were involved in this simulation; the desirability of the imitative strategy depends crucially on the assumption of minimal effects on performance from density increased dependence (cf. Hannan and Freeman, 1984).

Ambiguous condition

The results of this simulation also suggest recommendations about the management of

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However, it is clearly better to have at least a minimal level of entrepreneurial activity than none at all, given the outperformance of fixed firms by both imitative and adaptive firms.

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This simplification is being relaxed in current work by the authors.
discontinuous change when the relationship between firm characteristics and performance is ambiguous. The first and principal recommendation is that firms following an imitative entrepreneurship strategy should increase their levels of entrepreneurship at some point following a discontinuous change; however, they should not do so immediately following the change. Imitative firms should 'stay the course' until a stable industry leader emerges. In the results simulated here it was best not to move before period 70; this was the first period in which the performance of high entrepreneurship imitative firms first began to exceed the performance of low entrepreneurship imitative firms by a statistically significant margin. In the real world, one analogy to such a strategy might be to stay the course in the wake of an industry shake-up until a new industry leader emerges. How long this actually will take in a given field setting is an empirical question.

A second recommendation is based on the result that the differences in resources between adaptive and imitative firms are large and significant. Under conditions of ambiguity, adaptive search strategies should be avoided. The combination of costly change and ambiguity ravages the resources of adaptive firms: when change is costly, high variance search does not improve performance enough to warrant the drain on resources. Adaptive search processes will be especially costly when the technology linking organizational characteristics and outcomes is not well understood (Thompson, 1967). Imitative and fixed firms do significantly better than adaptive firms in terms of total resources; for some period of time after the discontinuous change, fixed firms do better than imitative firms as well. This illustrates two arguments offered by Hannan and Freeman (1984). The first is a variation on the liability of change argument, which is illustrated by the low level of resources among adaptive firms. This simulation was characterized by negative selection; that is, firms that went bankrupt were replaced. In a world where selection processes operated more competitively, firms with systematically low resource levels, in this case the adaptive firms, might be eliminated as well. The second is the argument that ambiguity will enhance the survival value of firms which do not change core dimensions. The mean resources of fixed firms are highest in the population from periods 20 through 100; the resources of this group are significantly better than the resources of both adaptive and imitative firms from periods 30 through 70.

Two fallacies in the system

The oscillation trap

The recommendation that fixed or imitative strategies increase total resources relative to the adaptive strategy in the high ambiguity condition is a direct result of the first learning fallacy implied by the theory; it is called the oscillation trap. Figures 15 and 16 display the plots of performance by high and low entrepreneurship adaptive firms as a function of time in the ambiguous condition. The average performance of both sets of firms oscillates between higher and lower levels over time following the discontinuous change. This results from a simple fallacy of an adaptive search strategy under conditions of ambiguity. If the organization is not a high-performance type, then even a noisy search process is likely to detect a change of organizational type that will improve performance. However, if the organization has found the best type, then by definition the long-run effect of any change will be to lower performance. This is why the mean performance by both high and low entrepreneurship adaptive firms oscillates: when adaptive firms have adopted good firm types, searching leads to more mistakes. After they have made these mistakes, however, searching is likely to lead to better types. These firms discover mirages of positive change possibilities even when they are in the highest performance type, and thus oscillate their structures too often. This result is consistent with the empirical observations of both Lorsch (1976) and Tushman and Romanelli (1985); it also suggests the dangers of an adaptive search rule in an ambiguous world. Under such circumstances, firms might be better off pursuing an imitative or fixed strategy.

\[12\text{It is interesting to note that the firms seem to have achieved a steady state before the discontinuous change; this is illustrated by the straightline tracking average performance between periods 10 and 20 in both plots. This result is consistent with popularized notions of chaos theory, which suggest that systems may not recover equilibria once they are disrupted.}\]
A comparison of the extent to which high and low entrepreneurship adaptive firms fall into this learning trap is also interesting. Low entrepreneurship adaptive firms, depicted in Figure 15, seem to suffer more from this phenomenon. After initially increasing performance following the change in periods 30 and 40, they experience a long decline in Periods 60 through 100. Further, the variance in performance of the low entrepreneurship adaptive firms is greater than that of the high entrepreneurship firms. This is unexpected, but understanding how the simulated process yields this result is instructive. The clearest interpretation of this result is to view it as one possible outcome in a trade-off between more or less search under conditions of ambiguity. High entrepreneurship among adaptive firms increases the speed with which they react to the environmental change. Thus, in the period of the discontinuous change they do somewhat better at finding good performing types than their low entrepreneurship counterparts. By the same token, they tend to start making mistakes more quickly than low entrepreneurship firms; this is illustrated by the significant performance differential in favor of low entrepreneurship adaptive firms in period 30. In the long run, however, the high entrepreneurship adaptive firms are able to discover their mistakes more quickly. Three pieces of evidence support this
conclusion. First, the resources of high entrepreneurship adaptive firms are no longer significantly lower than those of low entrepreneurship adaptive firms by the end of the simulation. Second, the performance among the high entrepreneurship firms begins rebounding by period 100, while the performance of the low entrepreneurship adaptive firms is still declining in period 100. Third, the lowest point in the performance cycle of high entrepreneurship firms is higher than that of the low entrepreneurship firms in period 100, which is not necessarily the bottom of the decline for low entrepreneurship firms.

Solutions to the oscillation trap are complicated by the fact that the very nature of ambiguity makes it difficult to detect valid signal from noise. Models of the engineering of choice (March, 1981) have examined the problem of how to optimize under conditions of imperfect information, e.g., Demski (1980: 29-33). However, the learning perspective developed here suggests that the assumptions necessary in order to apply such optimal solutions are frequently untenable in the real world. Under conditions of moderate ambiguity it may be possible to learn appropriate ways to use the information gathered in noisy adaptive search. As ambiguity increases, however, it may not be possible to pursue such strategies with any success (Harrison and March, 1984). Under such conditions, an imitative or fixed strategy may be preferable with respect to resources.

The follow-the-leaders trap

The second learning fallacy is the follow-the-leaders trap experienced by imitative firms. Figures 1 and 8 display the relationship between performance and the three entrepreneurial strategies in the wake of the environmental shock for the no-ambiguity and high-ambiguity conditions respectively. The pattern of results for imitative firms can be explained as follows. Following the discontinuous change, the firms which were previously the largest in the population are no more likely to be of a positive performing type than any other firm. Nonetheless, these firms maintain their industry leadership for some time, and continue to be mimicked by imitative firms. Thus, imitative firms tend to perform poorly after the discontinuous change because the largest firm in the population no longer provides a good signal to follow. The effect of this learning trap on performance is more pronounced in the high-ambiguity condition. The level of entrepreneurship among imitative firms is more pronounced in the high-ambiguity condition. In the ambiguous condition, however, the performance of high entrepreneurship imitative firms is significantly higher than their low entrepreneurship counterparts during certain periods following the discontinuous change; high entrepreneurship seems to pay off once a new, high-performing industry leader has emerged.

Relaxing the assumption that firms cannot change their search strategies, a possible solution to the follow-the-leaders trap might be the choice of some criterion other than largest resources to determine which firms are imitated. For example, imitation of the fastest-growing firm types might lead to avoidance of this trap under some circumstances. More generally, one way to avoid the follow-the-leaders trap is to not respond too quickly immediately following a major environmental change. Levitt and March (1988) give some specific examples of how learning too quickly can lead to poorer outcomes in the long run for organizations. Levitt and March (1981) discuss the implications of this argument with respect to technological innovation; this study provides an extension of this argument to administrative innovation in the wake of a discontinuous environmental change.

The lessons of past can harm the future

This study suggests several interesting speculations about how the experience of the immediate past can be a poor indicator of the future. In the high-ambiguity condition the recommendation was made that imitative firms should increase their level of entrepreneurship at some point following the discontinuous change. During periods prior to the shock, however, high entrepreneurship was associated with lower performance,
although this difference was not significant. If firms learn about entrepreneurship from their experience they might conclude from experience prior to the discontinuous change that high entrepreneurship is futile. This may make it less likely that they will raise levels of entrepreneurship following a discontinuous change.

Similarly, following the discontinuous change in the high-ambiguity condition, adaptive firms also may learn inappropriate lessons from their experience with high levels of entrepreneurship, largely due to the oscillation trap. When adaptive firms make mistakes in their searches and move away from good firm types, they may learn that high entrepreneurship does not pay. Once these firms have moved away from the types that perform well, however, the value of entrepreneurship increases again. Recent experience with disappointing results from high levels of entrepreneurship may make this difficult to recognize. As a result, managers at such firms may tend to lower their level of entrepreneurship; this would tend to move them onto the steeply declining performance curve of low entrepreneurship adaptive firms shown in Figure 15.

Important trade-offs

The key trade-offs in the determination of the appropriate content and levels of entrepreneurship in the management of discontinuous change should be highlighted. First, the trade-off between the costs of change and search and the improvement to performance is important. Second, the trade-off between the costs of change and search and the length of time until the improvement in performance allows recovery of those costs is also important. Third, there is a trade-off between the costs of high and low levels of entrepreneurship and potential performance benefits. Our results suggest that benefits from high entrepreneurship do not materialize in an unambiguous world. However, in the ambiguous condition, high levels of entrepreneurship resulted in occasional benefits. High entrepreneurship improves the performance of imitative firms once a new industry leader emerged, and appears to help adaptive firms avoid some of the swings in performance which result from the oscillation trap. Both of these examples illustrate the fourth trade-off: the length of time it takes for high entrepreneurship to pay off may vary longitudinally as a function of events such as discontinuous change. The inability to learn lessons of the past may make such time variation even harder to recognize. Fifth, there is also an important trade-off between the costs and benefits of the different search strategies. A fixed strategy avoids search and change; under conditions of ambiguity and relatively costly search and change, fixed firms had higher resources than adaptive firms. Fixed and imitative strategies avoid the oscillation trap experienced by adaptive firms, while fixed and adaptive strategies avoid the follow-the-leaders trap experienced by imitative firms. Thus, there are a variety of complex trade-offs between levels and types of entrepreneurial strategies. More careful examination of the conditions under which search and change will offer survival enhancement is needed (Singh, House, and Tucker, 1986). Future work should examine these processes under a wide range of cost functions, pay-off functions, and levels of ambiguity. In addition, future studies should examine organizations that change their entrepreneurial strategies and levels of entrepreneurship in response to experience. This paper has suggested several problems with applying lessons from past experience to the future. However, further examination of such learning processes in a variety of contexts may suggest ways in which organizations can avoid such problems.

Concluding points

This paper has used a computer simulation to explore the implications of an organizational learning model for entrepreneurship in organizations facing a discontinuous environmental change. The theory makes specific predictions regarding the types of entrepreneurial strategies and amount of entrepreneurial activity that are effective following such a change. Although this simulation has made several simplifying assumptions, the implications are striking with respect to the comparison of an ambiguous and unambiguous environment and with respect to certain fallacies, traps, and inappropriate lessons which seem to be inherent to the system. The theoretical perspective developed here should inform our theories of organizational learning and entrepreneurship and should help guide our empirical study of these phenomena.
APPENDIX: RULES GOVERNING SEARCH, LEARNING, AND CHANGE

Firm types and base performance

Firms are considered to be characterized completely by four dimensions; on each of these dimensions the firm has a value of one or zero. The result is 16 distinct combinations of zeros and ones, each of which represents a distinct firm type. Each type can be depicted as a unique four-digit combination of zeros and ones. The assignment of a base performance results in a random ordering of these firm types from highest to lowest performance. Base performance, denoted \( BP_{k,t} \), is a random draw from the uniform distribution of integers, \(-10\) to 10. This assignment is fixed in period \( 1 \) and remains stable for 24 periods; period 25 is when the discontinuous change in the environment takes place. At this time all 16 firm types are assigned a new base performance which again is a draw from the uniform distribution of integers between \(-10\) and 10. This relationship then remains fixed for the remaining periods of the simulation.

For example, in Table 2, upper panel, \( BP_{1,1} \) is \(-7\), \( BP_{2,1} \) is \(-9\), and \( BP_{16,1} \) is \(-7\). While the environment is stable, from periods 1 through 24, the relationship between each firm type and its performance does not change. However, when the environmental restructuring occurs, in period 25, the relationship between performance and firm type is likely to change; this is because the restructuring is operationalized as a random reassignment of firm types to performance. This is shown in Table 2, lower panel. Beginning in this period, \( BP_{1,25} \) is \(-8\), \( BP_{2,25} \) is \(-1\), and \( BP_{16,25} \) is 1. After this restructuring, the relationship between firm type and performance remains stable for the remainder of the periods.

The population of firms

One hundred and fifty firms are assigned randomly to the three entrepreneurial strategies; in addition, they are assigned randomly either a zero or a one for the four dimensions which characterize a firm. As a result, firms are distributed randomly across the 16 types in the initial period. Firms are given an initial resource allocation of 30; also, in the first period, firms are assigned a search potential, \( SP_i \), which is a random draw from the integers \(-1\) and 1.

Performance and resources

\( P_i \), the performance of firm \( i \) at time \( t \), consists of a systematic component, related to its firm type, and a random component which is different for each firm in each period. This is summarized by the following expression: \( P_i = BP_{k,t} + \mu_i \). As defined above, \( BP_{k,t} \) is the base performance of type \( k \) at time \( t \); the value of \( k \) depends on the type of firm \( i \). In the ambiguous condition \( \mu_i \) is zero; in the ambiguous condition \( \mu_i \) is a draw from the uniform distribution of integers between \(-25\) and 25 for firm \( i \) at time \( t \). Performance, whether negative or positive, is added to total resources in each period. The following expression describes this process: \( R_i = R_{i,t-1} + P_i \), where \( R_i \) denotes the resources of firm \( i \) at time \( t \), and \( P_i \) is defined as above. If a firm's resources go to zero or below, it is eliminated from the population. That firm is then replaced by a random draw from the surviving firms with positive performance at time \( t \).

Aspiration level updating

Aspiration levels are based on relative performance; specifically, the relative performance measure of interest is the resources of firm \( i \) at time \( t \) as a proportion of the maximum resources among all firms in the population at time \( t \). This quantity is denoted \( RP_i = (R_i/\max R_i) \), where \( R_i \) denotes the resources of firm \( i \) at time \( t \) and \( \max R_i \) denotes the resources of the largest firm at time \( t \). In the initial period, aspiration level \( AL_i \) is set to 0.5. In each subsequent period, aspiration levels adjust to the current performance by a weighted average formula as estimated from the data of Lant and Montgomery (1987):\(^{14}\)

\[
AL_{i,t} = 0.15736 + 1.0987(AL_{i,t-1}) + 1.2571(AD_{i,t-1})
\]

where \( AL_{i,t} \) is the current aspired level of performance for firm \( i \) at time \( t \). \( AD_{i,t-1} = \)

\(^{14}\) The constant term used here represents the actual estimate of the constant at a percentage of the average initial allocation of dollar to firms in the Lant and Montgomery (1987) sample.
$RP_n - AL_{n-1}$ is defined to be the attainment discrepancy in the last period, that is last period aspiration level minus the last period relative performance. $RP_n$ is the relative performance level, defined as above.

**Rules governing search**

Firms may search the environment for information about the relationship between the characteristics of firms and survival, size, or performance. In any period a firm may choose to expend resources on this type of search. The amount of resources dedicated to search by a firm depends on the amount of resources available. The maximum number of searches a firm will conduct in a given period is binomial with $n = 4$ and the probability of a search given by $\pi_n$. $\pi_n$ is defined to be equal to

$$RP_n = \frac{SP_n}{2}$$

with both quantities defined as above. Each search uses 1 unit of resources; this is the cost of search associated with examining each dimension of firm type in each period.

Four types of searches may take place. The first type of search involves examination of the types of firms that the searching firm would become by changing only one dimension of its structure. For example, a firm characterized by 1111 would look at types 1110, 1101, 1011, and 0111. The second type of search involves examination of all the changes of two dimensions. The third type of search involves examination of all the changes of three dimensions. Finally, the fourth type of search involves examination of the type that the firm would become if it changed all dimensions simultaneously. The relationship between the results of search and actual effects of these changes on performance will vary according to the type of world in which firms are imagined to be. The benchmark case is the pure selection world, where no search takes place.

**Fixed strategy**

In the population of firms using a fixed search strategy, search is conceptualized as taking place only during the period of founding. The search employed during the founding period is bounded and aimed at satisfying the criterion of finding a firm with positive performance in the current period. The firm then adopts the characteristics of this type. In the unambiguous condition this restriction ensures that firms with positive base performance will replace bankrupt firms. However, in the noisy condition a firm type with negative base performance which happened to get a highly positive random component can be chosen. After the period of founding, neither search nor change occurs. The population of fixed firms changes only through the selection process; that is, through bankruptcy and replacement.

**Adaptive strategy**

In the adaptive world, search is directed at discovering changes to the firm's type which will improve performance. Specifically, for a given number of changes, search is directed at discovering the best of these changes in terms of base performance. For example, if a firm is a 1111 the base performance of 1111 is compared with that of 1110, 1101, 1011, and 0111, to determine which change to a single dimension will enhance performance the most. Analogous processes take place for changes of two dimensions, and three dimensions; for the fourth dimension search involves the determination of whether changing all four dimensions simultaneously is likely to improve performance. Firms store this information; when the decision is made to make a certain number of changes to the characteristics of the firm, the results of search are used to choose from among change possibilities. The result is that the characteristics of firm types with high base performance are adopted. If two firm types, $k$, which is the current type of the firm, and $t$, some different firm type, are being compared, the process proceeds as follows. The firm measures the effect of changing from type

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15 Thus, search depends indirectly on whether performance is above or below aspiration level. However, no distinction is made here between problematic search, normally thought of as occurring when performance is below aspiration level, and slack search, normally thought of as occurring when performance is above aspiration level (Cyert and March, 1963).
$k$, its current type, to type $l$ by examining the following expression:

$$D_i = BP_{il} - BP_{kl} + \mu_{kl}, l \neq k$$

In the unambiguous condition $\mu_{il}$ is zero; in the ambiguous condition $\mu_{kl}$ is a draw from the uniform distribution of integers between $-25$ and 25 for firm $i$ at time $t$ and each type $l$ with which it compares itself. If $D_i$ is positive, then the number of changes, $NC$, required to change from type $k$ to type $l$ is counted. If $BP_{il} - BP_{kl}$ is the largest positive value among all changes which require the same number of changes as the transition from $k$ to $l$, then the result of search, $S_{NC}$, $NC = 1, \ldots, 4$, is the retention of the number of the firm type that will maximize the change in performance resulting from a change to NC dimensions of firm type. For example, a type 1111 operating under the relationship between performance and type depicted in the upper panel of Table 2 would have a value of 4 for $S_4$. This is true because the change of one dimension that would result in the biggest increase in performance would be to change to type 4 with a base performance of 9.

Ambiguity is defined as variance in the relationship between firm type and performance. In the unambiguous condition the random component, $\mu_{kl}$, is zero for all comparisons, thus the variance in the relationship between performance and firm type is zero. Firm type predicts performance perfectly. In the ambiguous condition, for each comparison done by firm $i$ at time $t$ the value of $\mu$ is a draw from the uniform distribution of integers between $-25$ and 25. The variance in the relationship between performance and firm type in this condition, $\sigma_{HA}$, is equal to the variance of this uniform distribution. The variance of a uniform distribution is equal to the range of the distribution divided by the square root of twelve, thus:

$$\sigma_{HA} = \frac{50}{\sqrt{12}} = 14.43$$

**Imitative strategy**

In the imitative world, search is directed at discovery of important aspects of the institutional environment, specifically the discovery of the prevailing practice among key firms (DiMaggio and Powell, 1983). Firms determine the most legitimized key firm, defined to be the largest firm in the population. The result of search for a given number of changes, $S_{NC}$, is zero unless that is the number of changes required to move to the firm type of the largest firm in the population. In this case, $S_{NC}^{*}$ is the number of the firm type containing the largest firm in the population. The result is a follow-the-leader strategy in which search is directed at determining the type of the largest firm in the population.

**Rules governing change**

**Failure-induced change**

In response to performance below aspiration level, firms increase their likelihood of changing some aspect of their type; each change to one of the core dimensions of firm type uses 10 per cent of the firms resources. The maximum number of changes that a firm will make in a given period, denoted $C_n$, is distributed binomial $(4, \pi)$. The determination of $\pi$ depends on whether performance is above or below the aspiration level. Failure-induced change occurs when performance falls below aspiration level; thus, these rules apply only if $AD_n < 0$. The number of changes they will consider is related to the size of the attainment discrepancy. $C_n$ is binomial with $n = 4$ and

$$\pi = \frac{-AD_n}{\max_i (-AD_n)}$$

Thus, the probability of a change in the firm's structure is equal to the negative of the attainment discrepancy as a percentage of the magnitude of the largest negative attainment discrepancy in the population at time $t$. Provided the $C_n$ observation from this distribution is greater than zero, firms make changes in accordance with the results of search. Adaptive firms will make $NC \leq C_n$ changes according to a comparison of the best change in performance that will result from making no more than $C_n$ changes. The imitative firms change if and only if $C_n \geq NC^{*}$ where $NC^{*}$ is defined to be the number of changes required for the firm to become the same type as the largest firm in the population.
In the absence of guidance from search, changes do not occur.

Slack change

A firm with performance above aspiration level will change under limited circumstances. Specifically, a random real number between 0 and 1 is generated. If that number exceeds 0.9 and the results of at least one search are greater than zero, then the firm will change.

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