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WHEN EXPLORATION BACKFIRES: UNINTENDED CONSEQUENCES OF MULTILEVEL ORGANIZATIONAL SEARCH

NICOLAJ SIGGELKOW
University of Pennsylvania

JAN W. RIVKIN
Harvard University

An enduring belief is that unleashing low-level members of an organization to explore extensively will broaden the exploration conducted by the entire organization. Using an agent-based simulation model, we show that in multilevel organizations, increased exploration at lower levels can backfire, *reducing* overall exploration and diminishing performance in environments that require broad search. This result arises when interdependencies cut across the domains of low-level managers. With no cross-departmental interdependencies, more extensive low-level exploration can improve firm performance. Our findings show that careful attention to information processing in multilevel organizations can shed light on whether, and when, decentralization encourages innovation.

Many organizations face the challenge of searching broadly for new configurations of activities. Broad exploration, spanning numerous individual activities, is particularly important in response to systemic innovations. Consider, for instance, the shift from mass manufacturing to "lean" manufacturing (Milgrom & Roberts, 1990). Early responses of the U.S. automobile industry to the lean techniques of Japanese automakers focused on piecemeal changes, such as investments in flexible machinery (Jaikumar, 1986). Such single-dimensional changes, however, did not improve performance significantly because they ignored the high interdependence within the lean manufacturing system. Only through broader search, involving coordinated changes to many elements of the production system, including supplier relationships, worker training, and inventory practices, were U.S. firms able to implement lean manufacturing techniques successfully (MacDuffie, 1995).

A common response among firms that need broader exploration is to adjust the locus of organizational search. Such firms often move away from employing a Tayloristic design, in which all exploration is conducted at the top of an organization and alleged solutions to problems are broadcast to the rest of the organization to be implemented, to a design in which greater exploratory search is conducted at lower levels of the organization. Solutions then "trickle upward" rather than downward (Burgelman, 1994). Low-level managers, it is argued, are closer to operational realities and are therefore better positioned to conceive of new alternative activity configurations than are members of top management. While empowering lower levels, most organizations retain a limited degree of control at a higher level. The main purpose of this oversight is to provide modest coordination and to prevent various departments of a firm from exerting negative externalities on each other.

Intuition certainly suggests that broadening low-level exploration and coupling it with higher-level coordination will broaden the exploration conducted by a firm as a whole. Yet intuition is a notoriously poor tool for predicting how organizations with multiple, interacting levels will behave. To test and refine intuition, we build in this paper an agent-based model of an organization with low-level search and high-level coordination, and we use it to investigate the effect that greater low-level exploration has on the exploration that an organization as a whole accomplishes. Even in our simple set-up, counterintuitive effects can arise. We find that, in multilevel organizations, increased exploration at lower levels can backfire, *reducing* overall exploration and

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thereby diminishing firm performance in environments that require broad search.

More broadly, our contribution is to marry two streams of prior work. One literature emphasizes that decentralization affects the propensity of an organization to explore broadly and to innovate. Another examines how multilevel organizations process information. We join these two perspectives to examine how exploration at one level affects exploration at another. Paying close attention to how information is exchanged between levels allows us to question whether, and when, decentralization encourages innovation. It also suggests that, if one seeks wide firm-level exploration, careful allocation of information-processing ability is more vital than sheer capacity.

PRIOR RESEARCH ON MULTILEVEL EXPLORATION

An enduring belief among management scholars and managers is that unleashing the low-level members of an organization to explore widely will broaden the exploration conducted by the organization as a whole. This sentiment has been expressed most passionately in the popular management literature. There, observers have argued that, when needing innovation, companies should "liberate" low-level managers (Peters, 1992), adopt "federal" structures in which "power belongs to the lowest possible point" (Handy, 1992: 62), and promote "activists" and "rebels" at low levels (Hamel, 2000). The freedom to explore that is granted to individual units, it is quietly implied, will aggregate to generate initiative and innovation for the entire organization.

Prior Research on Decentralization and Innovation

The scholarly literature has rarely explicitly examined the impact of low-level exploration on the exploration of an organization as a whole. The issue exists implicitly, however, in a rich stream of work on decentralization and firm-level innovation. To the degree that decentralization frees low-level managers to explore options broadly and to the extent that firm-level innovation is the fruit of firm-level exploration, one can interpret any positive association between decentralization and innovation as an indication that low-level exploration fuels firm-level exploration. And indeed, such a positive association has long been posited (Pierce & Delbecq, 1977). Centralized bureaucracies resist novelty, Thompson (1965) argued, whereas "organic" firms, with decentralized decision making, embrace innovation (Burns & Stalker, 1961). Decentralized firms, it is argued, are flexible and can adapt quickly to changes in local conditions (Child, 1984; Mintzberg, 1979). Similarly, Kanter found that innovation was "encouraged by . . . relative independence [of managers] from higher levels" (1985: 146) and by decentralization of resources, among many other factors.

The positive association between decentralization and innovation—and the implied relation between low-level and firm-level exploration—is in line with a long-standing intuition of practicing managers. Charles Perkins, the executive responsible for decentralizing the Burlington Railroad in the 1880s, justified the move in part with the logic that "such an organization encouraged initiative and independent thought" (Chandler, 1977: 181). To the present day, headlines such as "Ericsson Decentralizes for Quicker Research Payoff" (Blau, 1998) are not uncommon in the trade press. More rigorously, empirical support for a positive association has been shown in a group of social welfare organizations (Hage & Aiken, 1967), in a cross-industry sample of firms in Pennsylvania and Delaware (Russell, 1990), and in government departments in the United Arab Emirates (Mohamed, 2002), among others.[1] These precedents suggest:

> *Proposition 1a. Greater exploration at the lower level of an organization leads to greater exploration for the organization as a whole and improves the performance of an organization that requires broader exploration.*

A number of scholars have suggested, however, that the association between decentralization and innovation might not be robust. Hales (1999) argued that, following their "liberation," recently empowered managers may very well persist in their historical, noninnovative patterns of behavior. Kochen and Deutsch (1980), Kanter (1985), and Arnold (1992) worried that innovative efforts, left purely to semiautonomous business units, would focus too much on incremental improvement and short-term operating results. Case studies have also illustrated ways in which innovation in decentral-

[1] Most of the empirical support is based on cross-sectional, survey-based data. The studies report a positive correlation between decentralization and innovation and, in general, view the association as evidence that greater decentralization leads to greater innovation. The studies do not, however, compellingly rule out other paths of causation. Unobserved heterogeneity across firms and contexts, for instance, may induce a noncausal association.

ized firms may backfire.[2] In sum, then, although the assumption in most of the literature is a positive association between low-level and firm-level exploration, some scholars have suggested that greater low-level exploration might lead to exploration for a firm as a whole that is not enhanced, is excessive, or is misdirected. Such skepticism raises an alternative view:

Proposition 1b. Greater exploration at the lower level of an organization may fail to lead to greater exploration for the organization as a whole and might not improve the performance of an organization that requires broader exploration.

Prior Work on Information Processing in Multilevel Organizations

A largely separate body of work has examined why organizations come to have multiple levels and how multilevel organizations should be designed. For instance, Boulding (1964) proposed that a hierarchical structure is a device for resolving conflicts among subunits, to which Thompson (1965) added that conflicts are likely to arise if reciprocal interdependence among activities cannot be confined to activities *within* each subunit of an organization. (Subunits may be departments, divisions, functions, regions, product groups, and so forth. For convenience, we consistently refer to "departments.") This literature has addressed many issues, such as the organizational structures appropriate for various environmental and technical contingencies (e.g., Khandwalla, 1977; Lawrence & Lorsch, 1967; Woodward, 1965), yet the topic of exploration at different levels of an organization has attracted little attention.

One branch of the organizational design literature, however, can be employed to refine expectations about the relation between low-level exploration and firm-level exploration and, in particular, to allow us to hypothesize that the relationship depends on the nature of task interdependence. This branch of work treats firms as information processors (e.g., Galbraith, 1977; Tushman & Nadler, 1978), employing the overarching logic that "organizational effectiveness is greatest when the information processing capacities of the structure fit the information-processing requirements of the work" (Nadler & Tushman, 1997: 68). Key drivers of the need for information processing are the complexity and uncertainty decision makers face. Complexity and uncertainty, in turn, are driven partly by interdependencies among activities both within each department and between departments. Consequently, as intradepartmental or interdepartmental task interdependence grows, the need for information-processing capacity at the department level increases (Tushman & Nadler, 1978). Thus, this literature suggests:

Proposition 2. In the presence of high intradepartment task interdependence, a higher level of information-processing capacity at the departmental level improves organizational performance.

Proposition 3. In the presence of high interdepartment task interdependence, a higher level of information-processing capacity at the departmental level improves organizational performance.

According to the information processing branch of the organizational design literature, interdepartmental task interdependence not only increases the need for departmental information-processing power, but also the need for coordinative power. Indeed, Lawrence and Lorsch (1967), Khandwalla (1974), and Van de Ven, Delbecq, and Koenig (1976) found that departments facing substantial interdependence with other areas used complex coordination devices. Thus, this literature suggests:

Proposition 4. In the presence of high interdepartmental task interdependence, a higher level of coordinating-processing capacity at the top organizational level improves organizational performance.

We return to these propositions in our results and discussion sections. There, we describe and consider our finding that increasing lower-level processing power (captured by our notion of greater department-level exploration) can have counterintuitive effects when these departments are part of a larger hierarchical structure.

At a broader level, our analysis is very much in the spirit of Goodman's "linkage analysis," whose basic question was, "How are changes in activities and outcomes at one unit or level related to changes in activities and outcomes at another level?" (Goodman, 2000: 24). As did Goodman, we assume that an organization has been successful in achieving a

[2] For instance, Bartlett and Rangan (1986) described a country manager at Kentucky Fried Chicken who enjoyed great autonomy, innovated substantially, but veered so far from the company's traditional success formula that central managers grew concerned. Similarly, Schein (2003) examined how decentralized innovation at DEC led to a dizzying array of projects that baffled customers and undermined performance.

goal at one of its levels (in our case, increasing exploration at the lower level) and then ask how this success at one level affects a higher level, the firm as a whole.

Although Goodman did not identify information filtering as a mechanism that can create linkages between levels, a separate literature on multilevel organizations in which information flows up or down hierarchies (e.g., Argyris, 1953; Pettigrew, 1973) has pointed to the ability of managers to "filter and selectively provide information . . . [which] enables one to control the information and even the premises on which decisions will be made" (Pfeffer, 1978: 19). We emphasize this filtering ability below. These studies have focused on such issues as the effect of information distortion on optimal firm size (Williamson, 1967), yet they have generally not focused on firm search or innovativeness, nor have they examined the consequences of filtering as low-level exploration increases.[3]

Prior Modeling Efforts

To examine the effects of low-level exploration on firmwide exploration in the face of task interdependence, we employ a simulation model. This methodology enables us to incorporate more elements in our model of firm search than would be possible with a closed-form approach.[4] At the same time, it allows us to conduct a systematic analysis. Students of multilevel organizations have increasingly found computer simulations to be helpful for examining complex organizations "in silico," generating fine-grained predictions for empirical testing, and identifying boundary conditions of prior, less formal theorizing (e.g., Bruderer & Singh, 1996; Lant & Mezias, 1990; March, 1991; Rudolph & Repenning, 2002; Sastry, 1997; Zott, 2003).

In particular, we employ an *agent-based* simulation. Agent-based simulations are well-suited to examining how interactions among agents at one level of aggregation cause behavior to emerge at a higher level of aggregation. Prior agent-based simulations of organizations have focused largely on the consequences of the interactions among the decisions made within a firm and generally have not modeled multilevel organizations (Ethiraj & Levinthal, 2004; Gavetti & Levinthal, 2000; Levinthal, 1997; Marengo, Dosi, Legrenzi, & Pasquali, 2000; Rivkin, 2000). Exceptions include the work by Carley and Lin (1997) and Kim and Burton (2002), who were, however, not concerned with exploration or innovation but with the performance of different organizational forms under information distortion and task uncertainty. Chang and Harrington (2000) used an agent-based simulation to explore the impact of decentralization on innovation in a distributed retail chain. Although their focus was on the lateral, cross-unit transfer of effective practices, our model examines the vertical aggregation of exploratory behavior. In the work most closely related to the present study, we used a model similar to the one presented here to build hypotheses about the appropriate design of organizations in complex and turbulent environments (Siggelkow & Rivkin, 2005), rather than focusing on the impact of low-level exploration on firm-level exploration.

MODEL

To study the effects of low-level exploration on firmwide exploration, we created a simple simulation model that contained only the features essential to the problem at hand. Intentional simplification is a time-honored approach among simulation modelers (e.g., Cohen, March, & Olsen, 1972; March & Simon, 1958; Nelson & Winter, 1982) and is still strongly endorsed (Axelrod, 1997; Burton & Obel, 1995). In the next two sections, we describe the environments that our modeled firms face and their organizational arrangements.

Environment

Following a long tradition in the organization literature (e.g., Learned, Christensen, Andrews, & Guth, 1961) that has gained energy recently from empirical, prescriptive, and computational studies (e.g., Levinthal, 1997; Porter, 1996; Siggelkow, 2001, 2002), we conceptualize a firm's management team as facing a system of interdependent choices. The managers of a firm must make numerous decisions. Each firm must choose, for instance, how much to train its sales force, whether to field a broad product line or a narrow one, whether to pursue basic R&D or not, and so forth. Moreover, a number of these decisions interact with each other in influencing firm performance. For instance, the value of having a well-trained sales force might increase as a firm broadens its product line. A firm's environment is, in its simplest conception, a

[3] Williams and Mitchell (2004) looked at potential information distortion and its effects on product-market entry. They emphasized information distortion by top managers, whereas we focused on low-level managers.

[4] A review of related closed-form modeling efforts, mostly in the economics literature, is available from the authors.

mapping from the firm's set of interdependent choices to its performance.

In our model, each simulated firm must resolve N decisions designated by $a_1, \ldots, a_N$. For simplicity, we assume that a firm has two choices. For instance, a_1 might represent a decision to invest in more sales force training ($a_1 = 1$) or not do so ($a_1 = 0$), and a_2 might represent a decision to increase product breadth ($a_2 = 1$) or not ($a_2 = 0$). In total, thus, a firm has 2^N possible configurations of choices.

In computational studies of firms as interdependent systems, it has become common to visualize the payoffs to these choice configurations as a *performance landscape* (e.g., Levinthal, 1997; Rivkin, 2000). A performance landscape consists of N "horizontal" dimensions, each representing one of the N decisions a firm has to resolve, and one "vertical" dimension, which records the payoff to each of the possible choice configurations. A performance landscape is thus a mapping of any possible vector of firm choices, $\boldsymbol{a} = (a_1, a_2, \ldots, a_N)$, to a performance value, $V(\boldsymbol{a})$.

To study the effects of various organizational features relating to exploration, we send firms that differ in these features onto stochastically generated performance landscapes and record how well they perform. We create performance landscapes with a variant of the *NK* model (Kauffman, 1993), which has been employed in a number of organizational studies (for a survey, see Sorenson [2002]). In the model, the contribution of an individual decision—a_i— to firm payoff V is affected by both how the decision itself is resolved (0 or 1) and how K other decisions ($\boldsymbol{a_{-i}}$) are resolved. K parameterizes the degree of interdependence among a firm's decisions. If K equals 0, the contribution of each decision depends only on how the decision itself is resolved; that is, all decisions are independent. At the other extreme, if K equals $N - 1$, the contribution of each decision depends on how all other decisions are resolved. If one denotes the contribution of decision a_i by $c_i(a_i, \boldsymbol{a_{-i}})$, for each landscape, the particular values of all possible c_i's are determined by drawing randomly from a uniform distribution over the unit interval; that is, $c_i(a_i, \boldsymbol{a_{-i}}) \sim$ u[0, 1]. The value of a given set of choices $\boldsymbol{a}$ is then given by the average of the N contributions: $V(\boldsymbol{a}) = [c_1(a_1, \boldsymbol{a_{-1}}) + c_2(a_2, \boldsymbol{a_{-2}}) + \ldots + c_N(a_N, a_{\boldsymbol{-N}})]/N$.

The identity of $\boldsymbol{a_{-i}}$ (that is, the K decisions that affect the contribution of each decision a_i) is either determined randomly and anew for each performance landscape, or is explicitly specified and kept fixed. By averaging results over hundreds of performance landscapes, we ensure that results are not driven by particular draws of the contribution values.

Organizational Arrangements

In modeling firms that face these decision problems, we focus on a two-level structure, as was described briefly in the introduction to this article. In our modeled firms, explorative activity is conducted primarily at their lower levels. The main role of the upper levels is to coordinate low-level choices and to avoid negative externalities. The structure of the "ambidextrous organization," as described by O'Reilly and Tushman (2004), is a good example of such an organizational form. An ambidextrous organization consists of "teams that are structurally independent units" (O'Reilly & Tushman, 2004: 78). These teams are, however, coordinated at a higher level; i.e., "strategic integration . . . occurs at the senior team level" (Benner & Tushman, 2003: 247).

Specifically, we assume that decisions are split between two department managers. The first manager has responsibility for the first $N/2$ decisions, and the second manager has responsibility for the remaining $N/2$ decisions. In each period, each department manager evaluates a certain number of alternatives to the status quo within her or his department and ranks them from the most attractive to the least attractive for the department. For instance, if the firm has to make eight decisions, the first four of which are assigned to manager A and the second four to manager B, then manager A evaluates each alternative by computing $V_A = [c_1(a_1, \boldsymbol{a_{-1}}) + c_2(a_2, \boldsymbol{a_{-2}}) + c_3(a_3, \boldsymbol{a_{-3}}) + c_4(a_4, \boldsymbol{a_{-4}})]/4$, and manager B computes $V_B = [c_5(a_5, \boldsymbol{a_{-5}}) + c_6(\boldsymbol{a_6}, \boldsymbol{a_{-6}}) + c_7(a_7, \boldsymbol{a_{-7}}) + c_8(a_8, \boldsymbol{a_{-8}})]/4$.

In each period, each department manager considers and evaluates a given number of alternatives in his or her department. We parameterize the degree of exploration at the lower level of an organization with this number, which is designated *ALT* (for "alternatives"). Which alternatives a department manager can consider is determined by the degree to which his or her rationality is bounded (Simon, 1957). Managers with very bounded rationality can assess only alternatives that differ from the departmental status quo by a single choice. For instance, if the status quo choices are 0000, such a manager might evaluate 1000, 0100, 0010, or 0001. Managers with less severe bounds on their rationality are able to assess alternatives involving a greater number of simultaneous changes. The parameter *SEARCHRADIUS* is equal to the largest number of simultaneous changes to individual choices that a manager is able to contemplate.[5] Thus, *SearchRadius* captures the degree of bounded rationality. The larger this parameter, the greater the maximum number of alternatives that a manager can evaluate. For instance, if a manager controls four decisions and *SearchRadius* equals 1, the manager has only four alternatives within cognitive reach. In contrast, if *SearchRadius* equals 4, the manager has 15 alternatives to consider: 4 alternatives that differ from the status quo in the resolution of one decision, 6 that differ in two decisions, 4 that differ on three, and 1 that differs in all four. In each period, each department manager randomly picks a number of alternatives (*Alt*) from the set of alternatives determined by her or his rational bounds (as above, defined as *SearchRadius*, the largest number of simultaneous changes to individual decisions the manager can consider) and evaluates and ranks these alternatives. The manager then sends a given number of most preferred proposals (*P*) to the firm's upper-level coordinating body. For this exposition, we call this upper-level coordinating body "the CEO," though in reality it could be an entire senior team or some other source of central coordination. A low *P* reflects a firm in which managers are expected or permitted to narrow down options a great deal before turning to superiors. A high *P* reflects a firm in which senior managers want to review many alternatives themselves.

The CEO focuses on coordinating the actions of the firm's two departments. In particular, from all possible combinations of departmental proposals and status quo choices, the CEO selects a number of composite alternatives at random *(AltCEO)*, assesses them in light of the interests of the firm as a whole—that is, evaluates the overall $V(\boldsymbol{a})$—compares them to the status quo, and implements the option that yields the best payoff for the firm.[6] The configuration implemented by the CEO forms the starting point for further explorative search at the departmental level in the next period.

Overall, the organizational arrangements and decision processes we model are reminiscent of Bower's classic description of resource allocation processes: "Planning begins at some low level and moves up toward division management" (1970: 42). Moreover, "given the prevalence of 'bottom-up' planning, it is not impossible (nor really unusual) for interdependent . . . sub-units to develop plans that are inconsistent with each other" (1970: 47). The likelihood of conflict between plans creates a need for senior managers to exert discretion and to coordinate and select among the alternatives that department managers have proposed. In this classic description of resource allocation processes, senior managers select from among options already defined for them rather than explore independently: "Always the result of review was a 'go' or 'no go' response. The definition of a project did not change" (Bower, 1970: 65). Accordingly, in our model, new ideas originate only from department managers, not from the CEO.

Sticking Points

To interpret model results and, in particular, to measure firm-level exploration, we employ the concept of *organizational sticking points* (Rivkin & Siggelkow, 2002). These are choice configurations from which firms will not move.[7] Once a firm reaches a sticking point, its exploration stops. As a result, the count of sticking points is an inverse measure of a firm's average overall exploration. Firms with many sticking points are likely to get stuck very quickly, having explored very little of the landscape. Conversely, firms with few sticking points explore the landscape widely for choice configurations that produce high performance.

A firm can get stuck on particular choice configurations for two reasons: (1) given cognitive bounds, no department manager is able to find a profit-enhancing alternative, or (2) none of the proposals sent to the CEO are acceptable to him/her. For an example of the first kind, consider the production manager of a traditional mass manufacturer. This manager might find that—given the firm's current, specialized production facilities, Tayloristic human resource practices, and adversarial supplier relationships—a single change to

[5] For instance, a manager whose *SearchRadius* is 3 and whose departmental status quo is 0000 might consider options as different from the status quo as 1110 or 1011 (or alternatives closer to the status quo, such as 0011).

[6] Suppose, for instance, that the status quo choices for each department are currently 0000, that the manager of the first department has sent up 1000 and 0100 as proposals, that the manager of the second department has sent up 0001 and 0011, and that *AltCEO* equals 2. Then the CEO might consider the composite alternatives 1000-0001 and 0000-0011 and implement the composite alternative that yields the higher firm performance (or retain the status quo set of choices, should it yield higher performance).

[7] Formally, let $\aleph(\boldsymbol{a})$ be the set of all choice configurations that an organization might consider, given that its status quo choices are $\boldsymbol{a}$. For firms with top-level management that prevents the adoption of a performance-deteriorating alternative, a choice configuration $\boldsymbol{a}$ is a sticking point if $V(\boldsymbol{a}) > V(\boldsymbol{a}')$ for all $\boldsymbol{a}' \in \aleph(\boldsymbol{a})$.

any of these activities would not be beneficial. If the manager's cognitive bounds do not allow him or her to assess simultaneous shifts in all three activities, the firm might not be able to move to a lean manufacturing set-up with flexible machinery, participatory employment practices, and cooperative supplier relationships. The firm is stuck with its current set of choices. This type of organizational sticking point is akin to the "competence trap" discussed by Levinthal and March (1981) and Levitt and March (1988).

For an example of the second type of sticking point, consider the following situation involving a firm's marketing and manufacturing departments. The marketing manager weighs two options for his department: launching a price war or offering a longer warranty. Given the current low quality of the firm's products, the marketing manager recommends the price war to top management and steers clear of the longer warranty. At the same time, the production manager, knowing about the poor quality record of the firm's products, suggests a quality improvement program to top management. Top management reasons that the price war by itself would increase demand to an extent that it would put considerable strain on the existing production facilities, leading to inevitable backlogs and dissatisfied customers. Moreover, the price war coupled with the quality program, which would increase marginal costs, would be unprofitable. Lastly, the quality program by itself, without any additional benefits in the market, would also not pay for itself. As a result, top management rejects both proposals, and the firm is stuck. The combination of a longer warranty and an investment in quality might be profitable for the firm as a whole, but top managers never see this combination "bubble up" from the departments. The notion of sticking points captures these kinds of coordination failures that can arise in multilevel organizations with restricted information flows.

RESULTS

To study the effects of organizational features such as low-level exploration on firm-level exploration, we placed firms that differed on these features on the same, randomly chosen point of a stochastically generated performance landscape. We then observed each firm for 500 periods and recorded its performance in period 500, by which time it had reached a sticking point. The performance of each firm was measured as a portion of the highest performance attainable on the landscape. We repeated this procedure for 1,000 different landscapes and calculated the average performance of each type of firm across the landscapes. Below, we often report that one type of firm achieved higher performance than another. In each instance, the difference in mean performance was statistically significant at the .05 level.

For each firm, we set *N* equal to 8 and divided the decisions equally between the two managers described above, A and B.[8] Firms could differ from one another on four features: the extent of low-level explorative activity (*ALT*); the degree of bounded rationality of department managers (*SEARCHRADIUS*); the amount of high-level coordinative activity (*ALTCEO*); and the richness of information flow from department managers to the upper-level coordinator, the CEO (*P*). The impact of *ALT* was our central interest.

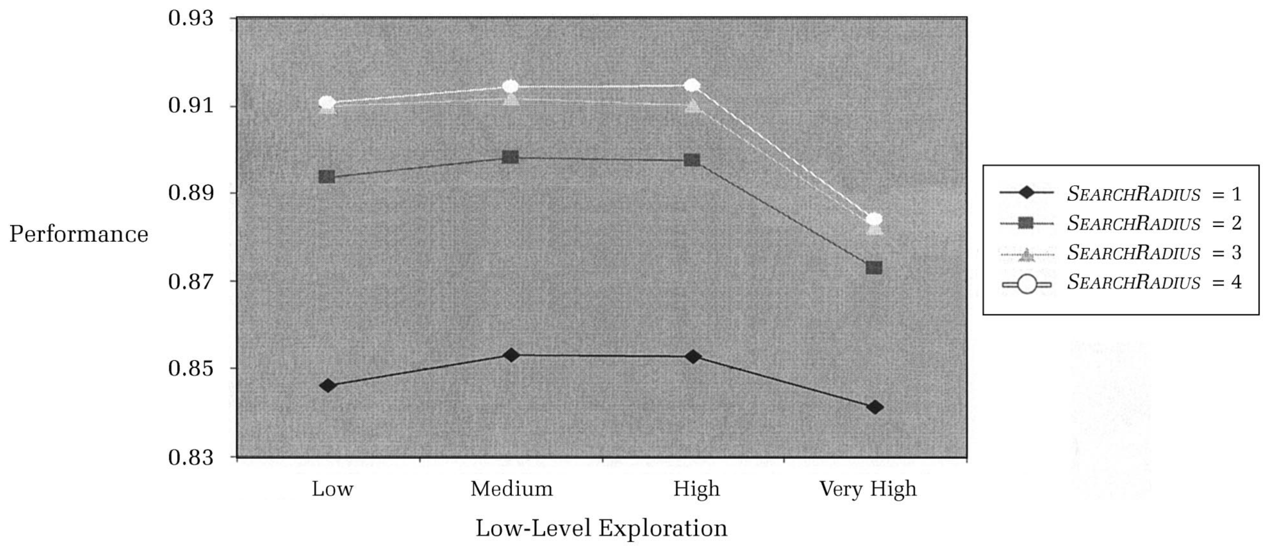
For each modeled firm, we considered four degrees of low-level explorative activity: low, medium, high, and very high. Since the set of possible alternatives grows as the bounds on managers' rationality become less severe, we set the values of *ALT* as a function of *SEARCHRADIUS*. In particular, if *SEARCHRADIUS* equaled 1, the four levels of low-level exploration were as follows: an *ALT* of 1 was considered low; an *ALT* of 2, medium; an *ALT* of 3, high; and an *ALT* of 4, very high. If *SEARCHRADIUS* equaled 2, the levels for *ALT* were 1, 4, 7, and 10; if *SEARCHRADIUS* equaled 3, the levels were 1, 4, 10, and 14; and if *SEARCHRADIUS* equaled 4, the levels were 1, 4, 10, and 15. Note that for each value of *SEARCHRADIUS,* the highest degree of exploration corresponded to evaluating all possible alternatives that were conceivable with that degree of bounded rationality. (None of the reported results were sensitive to the exact values of the intermediate levels of *ALT*.)

The Core Result: Low-Level Exploration That Reduces Firm-Level Exploration

The first type of firm we considered had department managers with tightly bounded rationality (*SEARCHRADIUS* = 1) who sent only their single, most preferred proposals ($P = 1$) up to the CEO, who, in turn, evaluated one composite alternative each period (*ALTCEO* = 1). We modeled four firms of this type with increasingly larger degrees of low-level exploration (*ALT*) and let these firms operate in landscapes that reflected a high degree of interdependence ($K = 7$). The results for these firms are

[8] Eight decisions allow an adequate range for the parameters in the model. Having more decisions increases the computational burden but does not change the reported results qualitatively.

FIGURE 1
Performance Implications of Higher Degrees of Low-Level Exploration[a]



[a] This figure reports the average performance of firms in period 500 over 1,000 landscapes with $N = 8$, $K = 7$. Firms differ in their degree of low-level exploration (*ALT*) and department-manager bounded rationality (*SEARCHRADIUS*). All firms have department managers who send up one proposal ($P = 1$) and CEOs who consider one composite alternative (*ALTCEO* = 1).

presented as the lowest line in Figure 1: as *ALT* increases, performance first increases, then plateaus, and eventually *decreases*. Thus, an increase in low-level exploration can undermine firm performance. This result favors Proposition 1b over Proposition 1a. Indeed, the result goes beyond Proposition 1b: the latter's argument is that increasing low-level exploration may fail to boost performance, but we find that extensive low-level exploration can *reduce* performance. Moreover, as the other lines in Figure 1 show, this effect does not vanish for managers with broader bounds on rationality (higher values of *SEARCHRADIUS*). Performance improves as bounds on rationality slacken (i.e., as *SEARCHRADIUS* increases) at any given degree of low-level exploration (*ALT*); but for any fixed degree of bounded rationality, performance still declines precipitously as low-level exploration reaches very high levels.

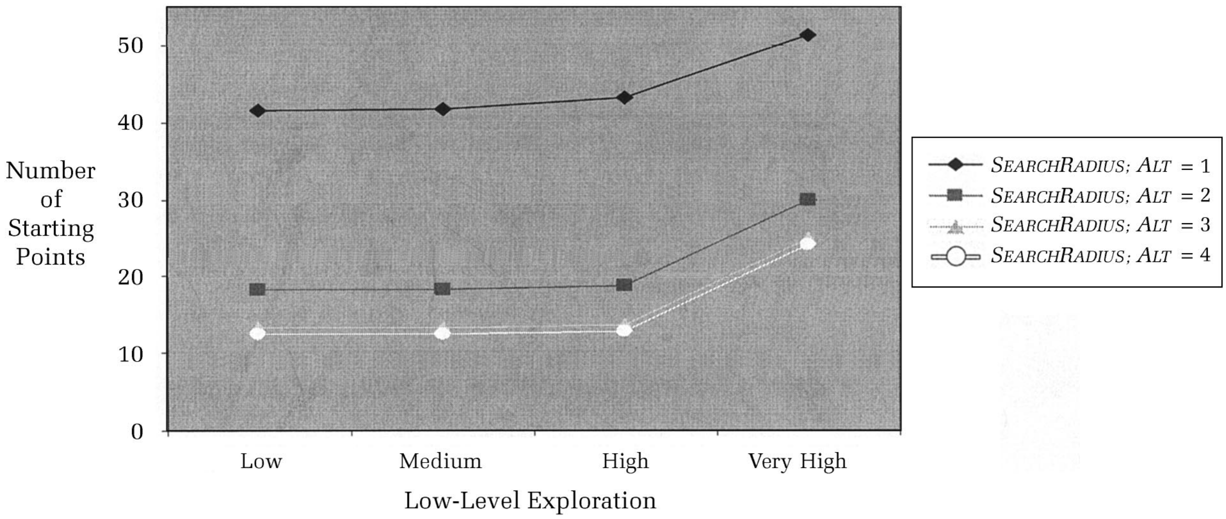
To uncover the reason for this performance decline, we examined the number of sticking points for each firm whose results were graphed in Figure 1.[9] Figure 2 shows that the number of sticking points increases as the degree of low-level exploration increases, especially once it reaches very high levels. Recall that the presence of many sticking points curtails firm-level exploration.[10] Thus, we find that *intense low-level exploration (high* ALT*) can lead to decreased exploration for a firm as a whole*, which in turn can lead to lower performance in environments marked by many interdependencies.

How can an increase in low-level exploration reduce exploration for a firm as a whole? Because department managers have a charter to evaluate and sort alternatives before proposing them to the CEO, they can screen out proposals they do not like and conceal them from senior management. The more department managers explore, the more completely they can screen. Figure 3 illustrates this effect. Given a *SEARCHRADIUS* of 1, a manager in one of the firm's two departments has four local alternatives that he or she might consider. Assume that three of the alternatives yield higher performance for the manager's department than the status quo, and one yields lower performance. Call the first three alternatives A1, A2, and A3, with A1 produc-

[9] We detected sticking points of a particular firm by determining for each location on a given landscape whether a firm could ever move from this choice configuration. Any location from which a firm never moves is a sticking point. Results in Figure 2 are averages over 1,000 landscapes.

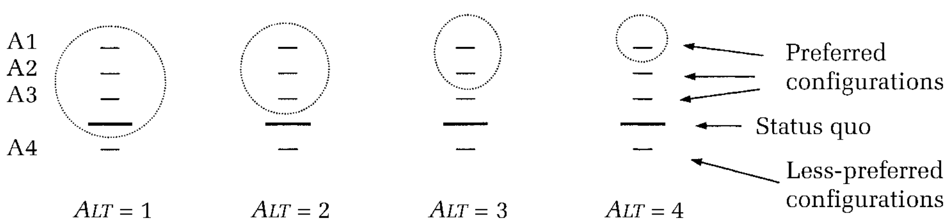
[10] To corroborate the inverse relationship between the number of sticking points and the degree of exploration, we considered a second metric for exploration: the average number of moves (i.e., changes in activity configurations) that a firm undertook before reaching a sticking point. The correlation between the number of moves and the number of sticking points was −0.90. Similar results arose when firms started their searches at the point furthest from the global peak.

FIGURE 2
Number of Sticking Points[a]



[a] This figure reports the average number of sticking points for the firms in Figure 1. $N = 8$, $K = 7$, $P = 1$, and *ALTCEO* = 1.

FIGURE 3
Screening Out Alternatives When *SEARCHRADIUS* and *P* Equal 1[a]



[a] The dotted circles contain all alternatives that a department manager might reveal to the upper-level coordinative body.

ing the highest performance for the department, and call the last alternative A4. In each period, each manager must send up one proposal ($P = 1$), which may be the status quo. If a manager evaluates only one alternative in each period (*ALT* = 1), he or she will send it up whenever it yields higher performance than the status quo. Thus, the manager might send up A1, A2, or A3. The CEO will never see A4, since the department manager will prefer to propose the status quo instead. This manager is thus able to screen out one alternative. Compare this situation to one in which a department manager explores extensively in each period (*ALT* = 4). Since the manager evaluates all possibilities, he or she will always spot his or her most preferred alternative, A1. Thus, A1 and only A1 will always be sent up (as long as the other department does not change its choices, which could change the preference ordering over A1–A4). In this firm, the department manager can shield A2, A3, and A4 from the CEO. This extensive shielding can lead to lower performance because, in situations in which many cross-departmental interdependencies exist, one of these alternatives might create a positive externality for the other department and might be a better alternative from the firm's point of view. In sum, the more extensive is exploration at the lower level, the more extensive is the screening that managers can engage in, leading to more sticking points and eventually to lower performance.

Low-Level Exploration That Enhances Firm-Level Utilization of Opportunities

Given that the number of sticking points always rises as the number of alternatives explored increases (Figure 2), an open question is why performance ever *rises* as low-level exploration increases, as it does when such exploration is changed from a low to a medium level (see the left side of Figure 1). This effect arises because a firm whose department managers conduct a great deal of exploration is able to better utilize opportunities. Imagine a firm with two superior sets of choices close to its current configuration. A firm whose department managers explore more extensively is more likely to spot the one with higher performance. Thus, a high degree of low-level exploration increases the likelihood that a firm takes advantage of existing valuable opportunities. Intuitively, if firms are close to two sticking points, the high-exploration firm will tend to evaluate both sticking points and pick the better one. The low-exploration firm may or may not evaluate the higher of the two and, as a result, might drift off to the lower-performing sticking point.[11] Thus, even though firms with higher degrees of low-level exploration (*ALT*) have *more* sticking points, they are more likely to reach *high* sticking points, especially if the sticking points lie close by. For instance, 58 percent of firms with *ALT* equal to 4 that are one step away from the global peak reach the global peak, but only 43 percent of those with *ALT* equal to 1 do so. At low levels of *ALT,* this second, positive effect can outweigh the negative impact of screening.

Overall, then, low-level exploration involves a trade-off. Greater low-level exploration allows a firm to better utilize existing opportunities, making sure that the highest configurations lying close by will be reached. At the same time, a greater degree of low-level exploration leads to more shielding of information from the upper level, which in turn reduces the likelihood that the firm will find even better configurations that are further away.

The Impact of Interdependencies on the Need for Low-Level Exploration

Propositions 2 and 3, which are based on the information processing literature, state that intra- and interdepartmental interdependencies both boost the need for low-level exploration. Here, in simulations that vary the degree and pattern of interdependencies, we find support for Proposition 2 but not for Proposition 3. Low-level exploration helps firms cope with intradepartmental interdependencies, but it undermines performance when interdepartmental interdependencies are pervasive.

To explore the impact of interdependencies, we first tested the robustness of our main result to changes in *K,* the parameter that controls the degree of interdependence. Up to this point, we had assumed a very rich interaction pattern, in which each decision affected all other decisions ($K = 7$). Intuition suggested that as the degree of interdependence decreased, the negative effect of screening would diminish. In the extreme case of complete independence among decisions ($K = 0$), one would expect no effect, as the most preferred option for each department would also be the most preferred option for the firm as a whole. Thus, although managers would still screen, their screening would do no harm. The results reported in Figure 4 confirm this intuition. At *K* equals 0 (complete independence), performance is unaffected by the extent of lower-level exploration (*ALT*). Moreover, each firm reaches the global peak. (One should note, though, that if decisions do not interact at all, the entire upper level of management is unnecessary. In that sense, it is not clear why one would have a multilevel organization to begin with.) For all other values of *K,* the main result—the negative effect of high degrees of low-level search on a firm's performance—is visible.

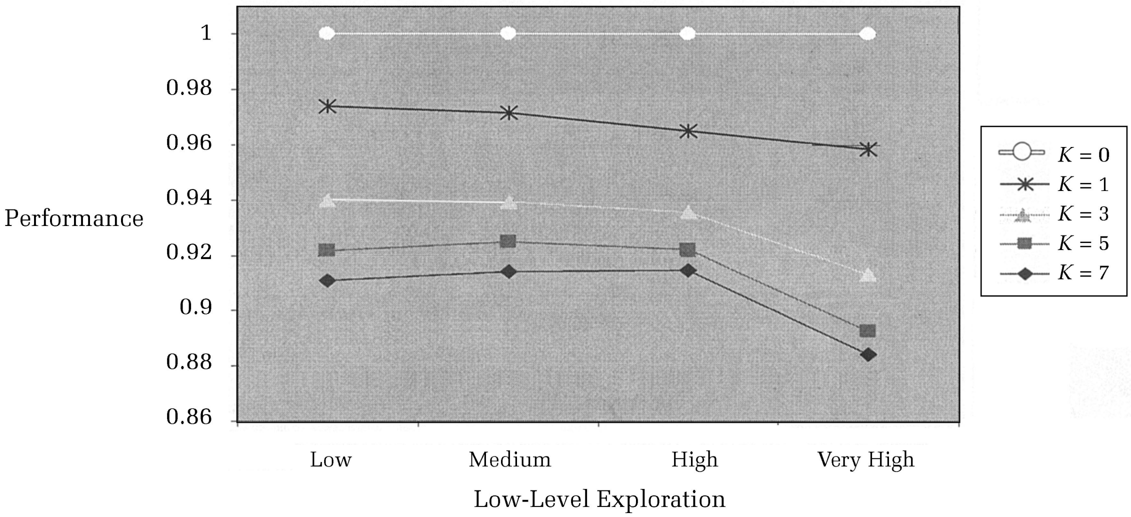
Such manipulations of *K* alter the density of both intra- and interdepartmental interdependencies, making it impossible to distinguish Proposition 2, which focuses on intradepartmental interdependencies, from Proposition 3, which emphasizes interdepartmental interdependencies. To make this distinction, we considered three patterns of interdependencies.

In the first pattern, *K* is 0: neither intra- nor interdepartmental interdependencies exist. As the top line of Figure 5 shows, firms reach the global peak in the long run regardless of their degree of lower-level exploration. Increasing low-level exploration has no effect on firm-level exploration or performance.

For the second pattern, we introduce interdependencies but force them to be intradepartmental. In particular, while each decision is affected by three other decisions ($K = 3$), decisions 1–4 each affect one another, as do decisions 5–8, but no interdependencies span those two sets. The middle line of Figure 5 shows that, now, low-level exploration benefits the firm as a whole. With no interdependencies between departments, each department manager operates with freedom, and the CEO always accepts the proposals he or she receives. After all, with no interdependencies, what is best for each department is best for the firm as a whole. No harmful screening occurs. Each department manager searches his or her own small landscape with

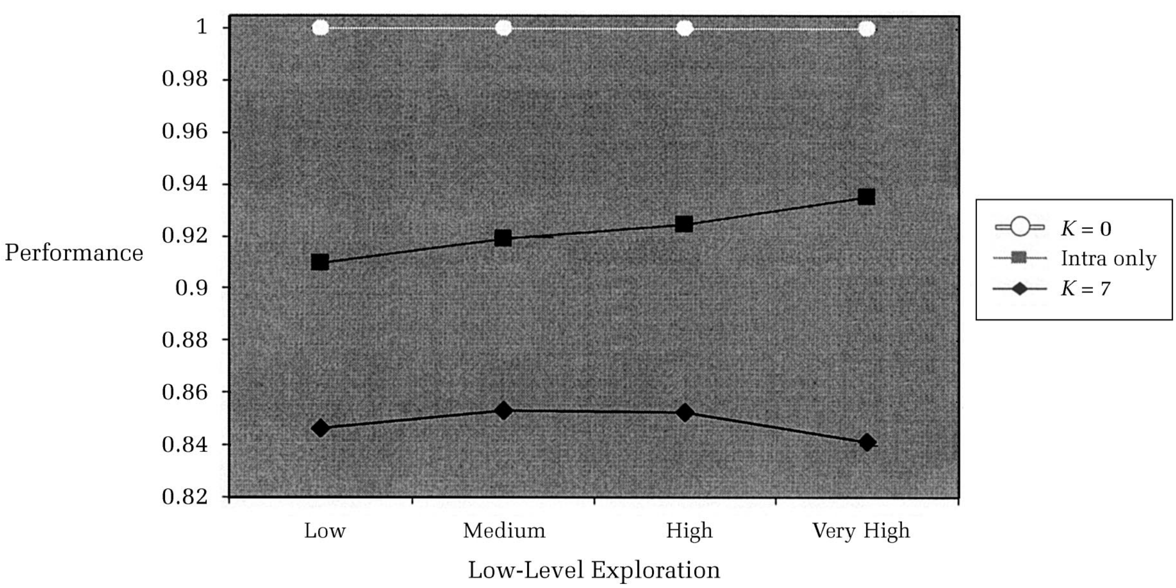
[11] This effect extends even to firms that are not located directly next to sticking points. For instance, assume a firm is located two moves away from two sticking points. The performance (or height) of the point between the current configuration of the firm and each sticking point lies between 0 and the height of the respective sticking point. The height of this interim point is higher on average for the higher sticking point. Thus, a firm that evaluates more alternatives and therefore climbs steeper gradients is more likely to reach the higher sticking point than is a firm that evaluates fewer alternatives.

FIGURE 4
Effects of Different Degrees of Interdependence[a]



[a] This figure contains the average performance of firms in period 500 over 1,000 landscapes with $N = 8$ and different degrees of interdependence (K). Department managers' bounded rationality is the same for all firms (*SEARCHRADIUS* = 4), and each department manager sends one proposal to the CEO ($P = 1$), who in turn considers one composite alternative (*ALTCEO* = 1).

FIGURE 5
Effects of Intra- and Interdepartmental Interdependencies[a]

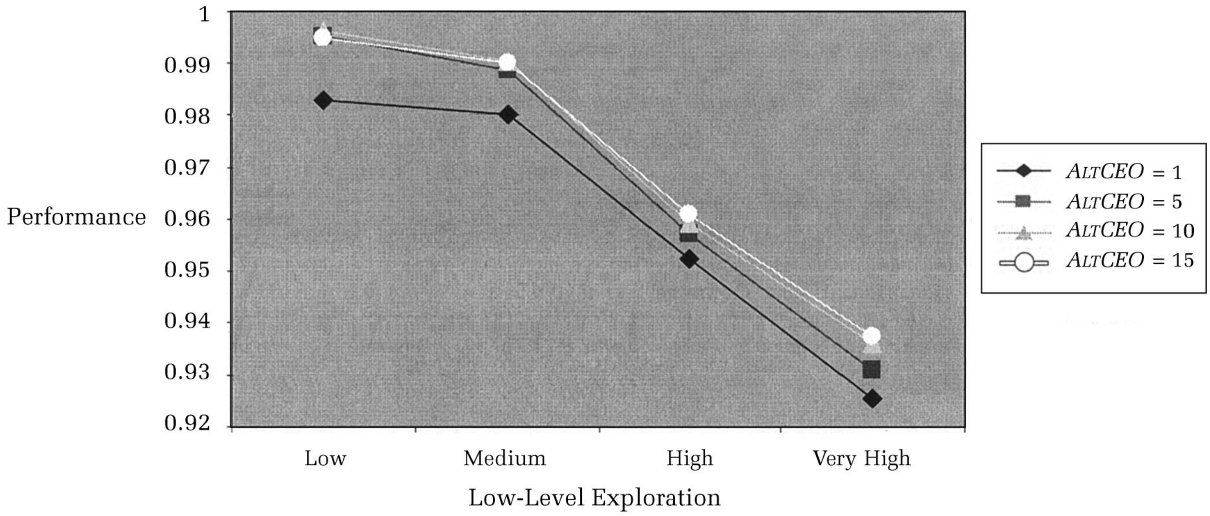


[a] This figure reports the average performance of firms in period 500 over 1,000 landscapes. The landscapes have $K = 0$, $K = 7$, or only intradepartmental interdependencies. Firms differ in their degree of low-level exploration (*ALT*). Department-managers bounded rationality is the same for all firms; (*SEARCHRADIUS* = 1) all department managers send up one proposal ($P = 1$) and all CEOs consider one composite alternative (*ALTCEO* = 1).

four "horizontal" dimensions, and interdependencies within each department create multiple local peaks on the departmental landscapes. Department managers with greater exploration (higher *ALT*) are more likely to spot steep inclines early in their searches and, thus, are more likely to migrate toward higher local peaks. (This is the same mechanism that generated the upward sloping portions of lines in Figure 1.) In sum, this finding affirms Proposition 2.

Finally, we raise K to 7, adding in the full set of interdepartmental interdependencies. This change returns us to the situation that produced our core result. As shown in the bottom line of Figure 5,

FIGURE 6
Effects of Greater Coordinative Activity[a]



[a] This figure reports the average performance of firms in period 500 over 1,000 landscapes with $N = 8$, $K = 7$. Department managers' bounded rationality is the same for all firms (*SEARCHRADIUS* = 3); each department manager sends three proposals to the CEO ($P = 3$); and all firms have high coordinative activity (*high ALTCEO*).

greater low-level exploration can now backfire, reducing performance. Interdependencies that span departments raise the specter of harmful screening. The addition of interdepartmental interdependencies reduces the optimal degree of low-level exploration, contradicting Proposition 3.

The Impact of Interdepartmental Interdependencies on the Need for Top-Level Processing

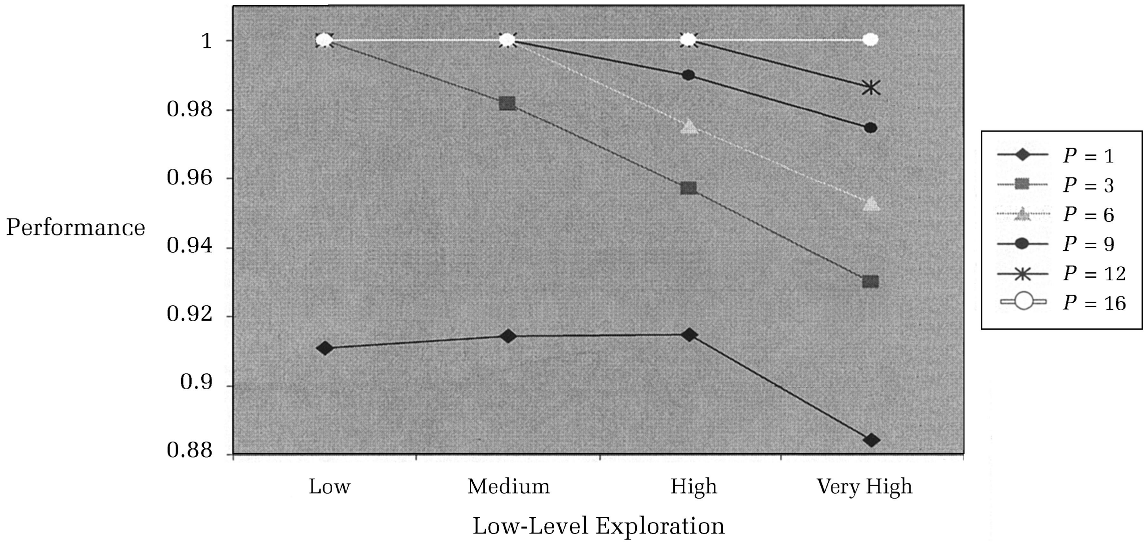
Proposition 4, also derived from the information processing literature, posits that interdepartmental interdependencies boost the need for top-level coordinative activity (*ALTCEO*). To study the effects of different levels of coordinative activity, we focused on the setting with the highest degree of interdepartmental interdependencies, $K = 7$, and considered CEOs who evaluate between 1 and 15 composite alternatives in each period. For the purpose of illustration, we report in Figure 6 results for firms whose managers have *SEARCHRADIUS* equal to 3 and send three alternatives to the CEO ($P = 3$).[12] (We found qualitatively similar results for other levels of *SEARCHRADIUS*.) Two results stand out. First, given any level of *ALT,* an increase in coordinative effort increases the ability of firms to take advantage of existing opportunities, thereby improving performance, albeit weakly. The underlying mechanism for the beneficial effect of top-level coordinative activity (*ALTCEO*) is similar to the mechanism previously outlined for the beneficial effect of greater low-level exploration (*ALT*): if a firm is located near several sticking points and has little top-level coordination, it might wander toward, and get stuck on, a low sticking point, whereas a similar firm with a great deal of top-level coordinative activity will tend to spot and pursue the higher sticking point. Overall, then, we found support for Proposition 4: greater processing power at the top level improves performance in the presence of interdepartmental interdependencies.[13]

The second main finding is that an increase in top-level processing power does not negate the detrimental effect that high degrees of low-level exploration can have on overall firm performance. The lines in Figure 6 continue to slope steeply downward, reflecting the more extensive screening that occurs as low-level exploration rises. The reason for this continued harmful effect is that an increase in top-level coordinative activity does not increase the overall exploration of the firm. Since new alternatives are generated only at the lower levels, the

[12] With P equal to 3, each manager might send up three proposals that are all different from the status quo. Since the CEO always has access to the status quo choices for each department, he or she has a maximum of $4 \times 4 - 1 = 15$ composite alternatives (besides the status quo for both departments) to evaluate.

[13] In the absence of interdepartmental interdependencies, the level of *ALTCEO* does not have any effect as there is no need for coordination between the two departments.

FIGURE 7
Effects of More Intensive Information Exchange[a]



[a] This figure reports the average performance of firms in period 3,000 over 1,000 landscapes with $N = 8$, $K = 7$. Firms differ in degree of information exchange (P) and low-level exploration (*Alt*). All firms have department managers with the same degree of bounded rationality (*SearchRadius* = 4) and CEOs who consider one composite alternative (*AltCEO* = 1).

amount of processing by the upper-level body does not broaden the set of alternatives that are considered. Thus, our core result is robust with respect to *AltCEO*.

A Further Robustness Check and a Boundary Condition of the Core Result

We have already shown that our main finding—that greater low-level exploration can lead to less exploration for a firm as a whole—is robust to changes in our parameters *SearchRadius, K,* and *AltCEO*. Here, we consider robustness along one further dimension: the richness of upward information flow (P).

Intuition suggests that as department managers share more information with the CEO of their firm, the screening effect declines. To test this intuition, we considered a firm whose managers have few cognitive constraints (*SearchRadius* = 4) and can send up to 16 proposals to the CEO.[14] As the results in Figure 7 show, the intuition that information exchange mitigates the effects of screening is only partially correct. Only at extreme levels of information exchange, when 16 proposals are sent up, does the screening effect vanish. At this point, though, the firm has essentially collapsed into a single decision maker, the CEO. He or she receives all possible alternatives from each department and has the opportunity to evaluate, over time, all possible combinations of these alternatives. The firm thus has ceased to be a multilevel organization. As long as $P < Alt + 1$, department managers have an opportunity to screen, and greater low-level exploration suppresses firmwide exploration. Indeed, as P increases from 1 to 3 or 6, the relative performance decline that occurs as low-level exploration increases becomes even more pronounced.

In sum, our core result proves to be very robust. Extensive low-level exploration ceases to suppress firm-level exploration and performance only when department managers must reveal so much information that they can no longer filter proposals or when decisions do not interact across department borders—two cases in which an organization may cease to be truly multilevel.

DISCUSSION AND CONCLUSION

Our model highlights a general tension that arises in organizations in which search is delegated. Firms often delegate search efforts in order to broaden search and to relieve the burden on top management. Delegation, however, inevitably empowers low-level managers to screen out alternatives, and this screening can narrow exploration for a firm as a whole. The more extensively low-level managers consider alternatives, the more effec-

[14] This assumption allowed us to examine the broadest range of information exchange, P. Results for lower levels of *SearchRadius* were qualitatively similar.

tively they can screen out options that do not serve their parochial interests. Ironically, then, more extensive exploration at a low level can reduce exploration for a firm as a whole and become a source of inertia.

With respect to the literature on decentralization and innovation, our findings affirm Proposition 1b: liberating low-level managers need not spark exploration for a firm as a whole. This conclusion shifts focus from the question "Does decentralization boost innovation?" to "*When* does decentralization boost innovation?" Our results suggest two hypotheses, both of which draw from the organizational design perspective that conceptualizes firms as information processors. Unleashing low-level managers is likely to raise firmwide exploration when decisions are well modularized—that is, when most interdependencies fall within the purview of individual low-level managers—but not when interdependencies span departments. Low-level exploration is also likely to boost firmwide exploration when department managers find it hard to hide options they do not like. This openness may occur because department managers are required to submit many proposals or because options considered but rejected by department managers get visibility.

Our findings also have implications for the information processing branch of the literature on multilevel organizations. Theoretical researchers who see firms as information processors can easily fall into the trap of assuming that "more is better" when it comes to managers' information-processing capacity, and that the more alternatives managers can consider, the better off their firm will be. The decentralization-innovation debate led us to question this notion. Our findings support this notion when interdependencies arise only within departments (Proposition 2) but refute it when interdependencies span departments (Proposition 3). With cross-cutting interdependencies, department managers may deploy increases in processing abilities to screen out parochially unwanted information, to the detriment of their firm. Our results also have implications for the allocation of information-processing capacity among levels of an organization. Basically, capacity in our model should be allocated to the locus of interdependencies: low in the organization when interdependencies are mostly intradepartmental (Proposition 2) and high when they are predominantly interdepartmental (Proposition 4). Overall, we affirm a long-standing sense among researchers that placing information-processing capacity carefully is more vital than increasing sheer capacity.

The following example illustrates the tension raised by low-level exploration, suggests some practical responses, and points out avenues for future research. In 1999, the Executive Committee of Whirlpool sought to encourage innovation "from everywhere and everyone" in order to escape a "stalemate" in its core appliance business (Rivkin, Leonard, & Hamel, 2005). Accordingly, it encouraged low-level exploration. Regional organizations set up "I-teams" to pursue innovations (hence the "I"), established "I-boards" to support the I-teams, created local seed funds for new ideas, and learned innovation techniques from consultants. The resulting burst of pilot projects covered a wide spectrum: a line of exercise equipment, a household maid service, a modular system of equipment for tailgate parties, and a service to bring chefs into homes for cooking parties, for instance. In some cases, exciting projects in "white spaces" new to Whirlpool were chosen over more mundane efforts close to the existing appliance business. Indeed, many projects were so far removed from Whirlpool's core business that, by 2001, the Executive Committee had to put new mechanisms in place to rein in the farthest-flung of the innovations. Subsequent efforts encouraged managers to tie their exploration efforts to existing brands. This narrowed low-level exploration but made it more relevant to the core of the firm.

The Whirlpool example suggests four practical responses to problems that intensive low-level exploration may raise, and four associated topics for future research. First, department managers might be given incentives to take firm-level interactions into account when they are evaluating and proposing alternatives—in Whirlpool's case, to consider the firm's core brands when deciding whether to launch a far-flung initiative. Such firm-level incentives mitigate the problem of parochial screening of information, but they dull department-level incentives and create a costly need to provide department managers with the expertise and information to take interdependencies into account. A fruitful avenue for future research would be to introduce firm-level incentives for department managers and to explore the trade-offs and tensions that result.

Second, a firm might avoid parochial screening by requiring department managers to send up a range of radically different proposals (a high *P*), particularly if prior proposals have been rejected. This requirement would ensure that a rich variety of ideas reaches the level of the organization at which firmwide implications can be assessed. Such a requirement, however, increases the coordinating and processing burden on top management. For instance, it is hard to imagine Whirlpool getting the hoped-for "innovation from everywhere and everyone" by having all 68,000 employees submit proposals, unfiltered, to the nine-person Executive Committee. Future research might examine how one can push proposals upward without overloading upper management. Bower's (1970) work suggests that models with more than two levels, in which middle managers act as broad-minded filters, might play an important role in such research.

Third, top management might define arenas within which low-level managers can explore freely. Such definition would make it less likely that senior managers would subsequently quash departmental initiatives. Whirlpool eventually took this approach, with the CEO identifying the existing brands as the "sandbox" in which regional innovators could "play." The approach puts some limits on exploration, of course, and it presumes that top managers have the information and insight necessary to spot the promising arenas for exploration. It suggests an extended model in which CEOs do more than combine and review proposals from below. Rather, they conduct their own high-level exploration and use the results to guide low-level exploration.

Last and most radically, one might remove the coordinating body, our CEO. Such decapitation would eliminate an important source of inertia: a CEO who retains the status quo rather than engage in any exploration that degrades performance. But such an organization would bear a severe risk of poor coordination among department managers. Identifying conditions under which this risk is worth taking is an promising avenue for future research, likely to shed light on the decentralization literature. We conjecture that decapitation would tend to look attractive in a model that encompasses environmental turbulence (occasional distortions to the performance landscape). In a turbulent setting, a firm must take advantage of local opportunities rapidly, before conditions change, and this exigency argues for removing the CEO. Turbulence might also make low-level exploration more beneficial than it appears to be in this paper's static model.

In sum, we see several practical responses that might mitigate the tension between low-level and firm-level exploration. None of the responses costlessly resolves the tension. All point to opportunities for future research and extensions to our model.

Even without these extensions, our results suggest a general conclusion that we believe to be broadly valid: one must be cautious when analyzing exploration in multilevel organizations. Interactions across levels may generate effects that run strongly against intuition. Outcomes at one level might or might not be echoed at an adjacent level (Goodman, 2000), so careful, rigorous analyses are required when forming hypotheses that span levels. The agent-based simulation tools used here provide one convenient way to carry out such analyses.

In sum, this study picks up on a suggestion in the decentralization literature—that efforts to boost firm-level exploration may fail—but it is unique in emphasizing how the interplay among multiple organizational levels may create this reversal. To the literature on multilevel organizations as information processors, we add a focus on exploration at various levels. There is novelty in our claim that exploration can be measured at different organizational levels and, indeed, may vary substantially among them. Moreover, we point out a dark side to greater information-processing capacity: capacity at one level may screen out the options and information available at a higher level. This scenario has implications for the allocation of processing capacity among levels. In general, we find support for the notion that capacity should be allocated to the locus of interdependencies. Our findings also contribute to the literature on decentralization and innovation. Prior work suggests that low-level exploration will boost firm-level exploration or, at worst, result in no-greater exploration. We find that the worst case is more extreme: when interdependencies span departments and department managers can screen out alternatives, greater low-level exploration may be worse for a firm, rather than neutral. Under a robust set of assumptions, sufficiently great low-level exploration can *reduce* exploration for a firm as a whole.

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Nicolaj Siggelkow *(siggelkow@wharton.upenn.edu)* is an associate professor of management at the Wharton School, University of Pennsylvania. His research focuses on the strategic and organizational implications of interactions among a firm's choices of activities and resources. His work analyzes organizational design, the evolution of firms' systems of choices, and firms' adaptations to environmental changes. He received his Ph.D. in business economics from Harvard University.

Jan W. Rivkin *(jrivkin@hbs.edu)* is an associate professor in the Strategy Unit at the Harvard Business School. His research and course development efforts examine how managers use strategy-making processes, organizational design, and cognition to cope with large sets of interactive decisions. He received his Ph.D. in business economics.