

# Cognition and Hierarchy: Rethinking the Microfoundations of Capabilities' Development

Giovanni Gavetti

Harvard Business School, Harvard University, 237 Morgan Hall, Boston, Massachusetts 02163,  
 ggavetti@hbs.edu

This article identifies gaps in the microfoundations of capabilities research, particularly in work that is based on the framework of evolutionary economics. It argues that such research has focused excessively on the quasi-automatic, routine-based aspects of capability development, and largely neglected the roles played by cognition and organizational hierarchy. By deriving a model of search that jointly considers how routine-based and cognitive logics of action coexist within an organizational hierarchy to affect capability development, this article offers three contributions. First, it delineates the traits of a microfoundational structure for research on capabilities that begins to address these gaps. Second, based on this structure, it highlights previously neglected causal mechanisms that contribute to our understanding of how capabilities develop. The model shows that managers' cognitive representations of their strategic decision problem fundamentally drive organizational search, and therefore the accumulation of capabilities. Furthermore, it shows that the accuracy of the representations a manager chooses might vary according to where she is situated in the organizational hierarchy. This more refined perspective leads to a set of propositions regarding how different hierarchical arrangements influence capability development and organizational performance. Finally, the paper sets an agenda for future research in this area.

*Key words:* capabilities; organizational search; cognition; hierarchy

## Introduction

The premise of this paper is that research on capabilities needs microfoundations that capture more fully what we know about cognition and action within organizations. As recently pointed out (Gavetti and Levinthal 2004), a large, growing body of research on capabilities rests on, or is highly influenced by, the routine-centered microfoundational apparatus of evolutionary economics (Nelson and Winter 1982). Routines and the related notions of local, experiential, semiautomatic search are powerful concepts. They provide a parsimonious explanation of what may be the central feature of capabilities' macroevolutionary characteristics: their continuity. However, a too extensive focus on these forms of behavior comes at the expense of obscuring other important mechanisms that affect capabilities' dynamics. Scholars have long argued that routine-based logics of behavior are intertwined with more cognitive, calculative ones (March and Simon 1958, March and Olsen 1976, Glynn et al. 1994). Furthermore, these processes occur within organizational hierarchies, and close attention to the hierarchy's role is needed to capture their phenomenology (Simon 1976). Although the idea that the triplet of routines, cognition, and hierarchy should be given joint consideration lies at the roots of the Carnegie school (Simon 1976, March and Simon 1958, March and Olsen 1976), developments in this tradition, particularly formal ones, have generally not considered this triplet properly.<sup>1</sup> The intellectual lineage of evolutionary

economics exemplifies this tendency. This perspective's need for a stark formal apparatus led to the choice of oversimplified behavioral foundations (Nelson and Winter 1982), and the effects of this choice remain embedded in current theoretical and empirical work on capabilities. To address this microfoundational gap, I derive a formal model of search that considers experiential, semiautomatic, and calculative forms of behavior, and how they play out in organizational hierarchies. The objective is a descriptively more powerful characterization of what drives capabilities' development.

"To be capable of some thing is to have a generally reliable capacity to bring that thing about as a result of intended action" (Dosi et al. 2000, p. 2). As two decades of research demonstrate,<sup>2</sup> the central dynamic property of this reliable capacity is its continuity. That is, capabilities have been shown to accumulate gradually within organizations, and to be highly specific to the context in which they develop (Argote and Darr 2000, Narduzzo et al. 2000). Capabilities' inertial, path-dependent properties make their transfer across organizations and markets challenging, particularly across "distant" contexts (Argote et al. 1990, Szulanski 1996), thereby putting a premium on diversification strategies that are *coherent* in the knowledge they require (Rumelt 1974, Teece et al. 1994). Relatedly, new entrants' backgrounds in regard to their capabilities have been found to have profound effects on their performance: In a number of new industries, preentry experience in "related" domains has been

a key to competitive advantage (Mitchell 1989, Klepper and Simons 2000, Klepper 2002).<sup>3</sup> For similar reasons, organizations have trouble developing new capabilities when market or technological changes render their old ones obsolete (Tushman and Anderson 1986). This research largely supports the fundamental proposition of evolutionary economics, namely that interfirm heterogeneity resides in distinctive ways of doing things that are largely continuous and context specific. Indeed, continuity is intrinsic to capabilities' ability to confer *lasting* competitive advantage: To the extent that a firm's competitive advantage is rooted in its capabilities, their continuity is a powerful deterrent to imitation (Winter 2000). However, continuity also undermines a firm's ability to survive changing environmental conditions (Teece et al. 1997). It is thus vital to understand what drives this continuity.

Capabilities' path-dependent attributes have long been linked to bounded rationality (Simon 1955). Because individuals can consciously process only a limited amount of information, much behavior in organizations rests not on calculative rationality, but instead, on rules (March et al. 2000) and routines (Nelson and Winter 1982), highly tacit and repetitive "chunks" of coordinated activity that are taken as a primitive in the definition of capability (Cohen et al. 1996). Both experimental and field-based evidence support this proposition by showing that gradually evolving routinized behavior can lead to high competence in complex decision settings (Cohen and Bacdayan 1996, Narduzzo et al. 2000). Critical to these accounts is the local and experiential nature of the search mechanisms that are thought to guide routines' dynamics. As Nelson and Winter (2002, p. 29) note: "Learning guided by clear short-term feedback can be remarkably powerful, even in addressing complex challenges. But that sort of learning does little to enable sophisticated foresight, logically structured deliberation and/or the improvisation of novel action patterns—and situations that demand these are rarely handled well." These behavioral foundations are also central to literature on dynamic capabilities, which focuses on how firms can change their capabilities fundamentally by creating "dynamic" or "higher-order" capabilities. Although much of this research views managers as able to create dynamic capabilities deliberately (Eisenhardt and Martin 2000), it usually conceives these capabilities in terms of routines or procedures designed to overcome the local nature of learning that ordinary routine operations involve (Teece et al. 1997). That is, the problem that a dynamic capability is to solve is typically framed in terms of the foregoing behavioral foundations, and the dynamic capability itself is conceived as a routine (Winter 2003).

In contrast, empirical accounts of behavior in organizations suggest that behavior is often cognitive and calculative (Simon 1955, Porac et al. 1989), and not

only at the level of strategic decision making. Routines evolve through local search because of bounded rationality, and because "users" of the routine may mindfully alter it. Routines may thus reflect both emergent and effortful properties (Feldman 2000, Edmondson et al. 2001). Indeed, bounded rationality itself does not preclude behavior that is premised on a logic of consequences (March and Simon 1958, March 1994), and many scholars have argued that it is important to integrate this logic with a routine-based logic of behavior (March and Olsen 1976, Glynn et al. 1994). In this vein, Gavetti and Levinthal (2000) propose that a forward-looking logic of consequences and a backward-looking logic of experience should be used jointly to understand the phenomenology of organizational search. Their model emphasizes the interplay between cognition and action, between thinking and experiencing. The boundedly rational managers that they model think along the lines of simplified representations of their decision problem. These thought processes lead to strategic directions that guide local search, the central mechanism through which routines evolve.

In addition, the interplay between cognitive and experiential, semiautomatic forms of behavior suggests the need for more explicit attention to the role of the organizational hierarchy than most theory on capabilities implies. In a hypothetical world in which local and automatic change dominates, the role of "external" interventions to alter the routine or capability at hand is minimal (Winter 1987). In contrast, allowing for other mechanisms of change such as cognition introduces the possibility that cognitive effort occurring at multiple levels in the organizational hierarchy affects capability development. If cognition is "situated" (Dearborn and Simon 1958), and thinking and interpreting depend on the actor's position within the hierarchy, then different organizational arrangements might affect capability development in profoundly different ways (Burgelman 1988). For instance, the intensity of *decision premises* (Simon 1976, Ocasio 1997) or, more broadly, the strength of influence from the top, may differ widely across organizations, with relevant consequences on what beliefs affect search and the evolution of capabilities.

In sum, to develop more behaviorally plausible microfoundations for research on capabilities, it is essential to consider cognitive and more automatic search processes jointly, as well as the role of hierarchy. Signaling the importance of the gaps discussed above, some work in this domain has recently noted cognition's importance, and considered its consequences for the dynamics of capabilities. For instance, Adner and Helfat (2003) and Helfat and Peteraf (2003) argue that managerial cognition is relevant, particularly in the early stages of capability development. Dyer et al. (2001) and Zollo and Singh (2004) advance similar arguments in their research on the development of joint-venture and integration

capabilities, respectively. Eisenhardt and Martin (2000), Tripsas and Gavetti (2000), and Kaplan et al. (2003) suggest that cognition at the senior management level critically affects how established firms respond to discontinuities. What this work does not offer, however, is a foundational discussion of how cognitive and routine-based forms of behavior interact (see Winter 2000, Zollo and Winter 2002 for exceptions), especially within organizational hierarchies.

This paper begins to address these gaps. In doing so, it contributes to two theoretical perspectives. As discussed above, the primary contribution is to research on capabilities that is informed by evolutionary economics. The paper also contributes to organizational ecology research, which regards selection as the primary mechanism by which organizational populations change. Early work in this stream of research, which takes structural inertia as a foundational axiom, emphasized the process and overlooked the content of organizational change (see Barnett and Carroll 1995, Carroll and Hannan 2000). Process is important; by modifying its core elements, an organization typically generates a cascade of internal changes that in turn reduce its odds of survival. However, given a level of process disruption, the content of change significantly affects an organization's survival prospects. Recognizing the importance of content, some later research in this tradition (e.g., Amburgey et al. 1993) began considering it simultaneously with process. Here, my emphasis is consistent with this more recent work, but I identify an overlooked dimension of the process-content link. I show that process significantly affects how the quality of content is determined. In particular, I show that how information is processed within organizational hierarchies (process) profoundly influences the choice of cognitive representation, which in turn affects what capabilities are eventually developed (content), thereby impacting organizational survival.

To fulfill these goals, I use an agent-based simulation model of search. The model's structure and the nature of the simulation analysis are inspired by a field study of Polaroid's response to the shift from analog to digital imaging. The model considers different organizational arrangements, or alternative "regimes of corporate influence," and studies their properties in terms of capability development. It asks under what conditions certain regimes are preferable to others, and why. To address this question, I model thinking as occurring at multiple hierarchical levels. Additionally, cognition's effects on local search hinge on the particular regime adopted. This structure lets me isolate causal mechanisms that are central to capability evolution but are generally neglected by the current microfoundational apparatus of capability research. First, the simulation analysis illustrates the role of cognition in capability development. Second, it illuminates how experience influences the formation of cognitive representations and strategic beliefs. In particular,

it sheds light on how and why this linkage differs by hierarchical level. My results show that managers' ability to interpret their company's experience varies profoundly across hierarchical levels, and explain why it is more difficult for higher-level actors to interpret feedback from action than it is for lower-level actors. These results inform propositions about the effectiveness of different regimes of influence. To sum up, by extending microfoundations on capability research, this formal structure and analysis highlight important, but largely forgotten, causal mechanisms in capability development, and set an agenda for future work.

The next section summarizes Polaroid's foray into digital imaging, introduces the key modeling choices, and discusses their relationship to the field study. I next describe the model in more detail, before moving to the simulation analysis. I conclude by discussing the implications of this theory-building effort.

### Deriving the Model

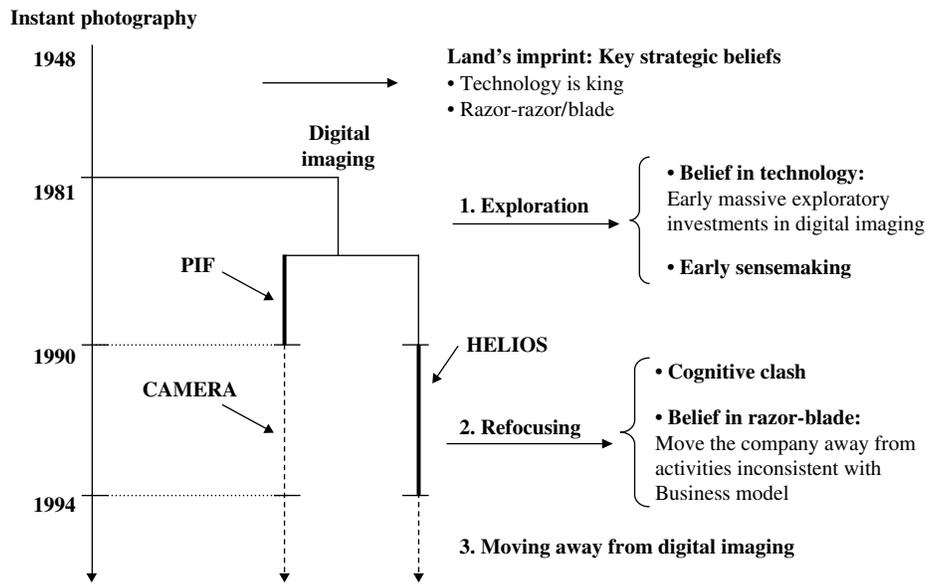
To flesh out the modeling criteria, I ground the discussion in a case history of Polaroid's transition from instant to digital imaging. This history highlights the importance of filling the aforementioned gaps. It greatly influenced how I structured the model and simulation. Here, I report a stylized version of the story (see Figure 1 for a roadmap) and discuss how it influenced my model. This account draws on extensive fieldwork at Polaroid from fall 1998 through fall 1999. A comprehensive description of the research procedures, and a more detailed account can be found in Gavetti (2000) and Tripsas and Gavetti (2000).

### Grounding the Discussion: Polaroid in Digital Imaging

Polaroid, founded by Edwin Land in 1937, introduced the first instant camera in 1948. Driven by instant-imaging products (camera and film), it was very successful until the early 1990s. As Polaroid grew, its senior managers developed strong beliefs about how to do business in the photography industry. First, they firmly believed that all the profits in this industry were in the consumables. In fact, to maximize sales of its film, Polaroid began selling cameras at cost in the mid-1960s. Reinforced by years of exceptional performance, Polaroid never challenged its "razor/blade" business model before it moved into digital imaging. Second, Polaroid's managers considered the company technology-driven, and believed its commercial success originated only from technological breakthroughs. Not surprisingly, the first signs of market weakness in instant photography in the early 1980s led Polaroid to explore digital-imaging technologies to have another such breakthrough.

*The Exploratory Phase: 1981–1989.* In 1981, Polaroid created an electronic-imaging group to explore digital-

Figure 1 Polaroid in Digital Imaging



imaging technologies. In the following years, despite the lack of a market for digital-imaging products, it spent a significant amount on R&D to develop basic knowledge and capabilities in digital imaging. Although this search effort was exploratory, the electronic-imaging group was driven by a major project dubbed “Print in the Field” (PIF), which was intended to develop an instant digital camera/printer. Because the digital camera was to print on Polaroid’s paper, PIF had a clear consumable component and so was consistent with the company’s razor/blade model. Polaroid also allocated resources to Helios, another digital product that it hoped would replace traditional X-ray technologies. Like PIF, Helios was designed to make money on the film.

During this period, digital-imaging managers, who were long-term employees at Polaroid, began to question the strategic implications of digital imaging. They embraced a business model that would make hardware more central. However, because both PIF and Helios were consistent with the razor/blade model, the conflict between senior managers—who still believed in the razor/blade model—and managers espousing the “hardware model” was not overt. By 1989, Polaroid had developed leading-edge capabilities in several areas of digital imaging. Polaroid’s image sensor technology, the heart of the digital camera, was considered among the best in the industry.

*Refocusing Digital Imaging: 1990–1993.* Insurmountable technical problems led Polaroid to abandon PIF and focus on a digital camera with no printing device. By 1992, the company had a working prototype of a digital camera that substantially improved the price/performance ratio relative to similar products by competitors. Digital-imaging managers believed that this camera was crucial to a foray into the consumer market, where they

wanted to play a leading role. Senior managers, however, opposed a camera with no printing device, as it clashed with their belief in the razor/blade model. They did not abandon this model, despite their ongoing dialogue with digital-imaging managers, who provided continuous evidence of how the emerging digital-imaging landscape was at odds with a software-centered view. This disagreement delayed the development and commercialization of the digital camera. It also pushed search efforts toward digital-imaging products that were in line with the razor/blade model, particularly Helios, which reached the market in 1993, but failed despite its technological breakthroughs.

*Moving Away from Digital Imaging: 1994–1998.* The fallout from Helios’s failure and the inconsistency of the other digital-imaging activities with the traditional business model led to Polaroid’s move away from digital imaging. In late 1993, the company began to dismantle much of its electronic-imaging division and soon afterwards sold the Helios division. It did not sell its megapixel camera until 1996. By that point, more than 40 firms were selling digital cameras, and Polaroid’s did not sell well. The limited success of Polaroid’s camera and other digital products was also attributed to the firm’s approach to sales. Senior executives pressured the digital-imaging group to sell its products through the existing sales force and marketing channels (mass retailers such as K-Mart and Wal-Mart), which proved to be problematic because the merchandise was sophisticated, expensive, and used complex technology. By 1998, Polaroid’s earlier strength in digital imaging had significantly diminished; it had only 50 employees working on digital imaging and had begun to sell digital cameras that were produced by a Japanese competitor under Polaroid’s name.

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### Key Modeling Criteria

These stylized facts highlight the limits of viewing capability development only through the lens of local search and suggest concrete avenues to tackle these problems. First, they show a crucial role for cognition. Polaroid's early development of leading-edge technological capabilities in digital imaging is hard to explain without considering the belief in technology's primacy. For over a decade, this belief led to massive investments in search efforts despite the lack of a tangible financial payoff. Then, when a market for digital products emerged, senior managers discouraged search activities that were inconsistent with their theory of how to be profitable in the photography business, effectively destroying Polaroid's core digital-imaging capabilities. This evidence suggests that cognition can be central to capability development by affecting the search efforts undertaken.

At another level, these facts suggest a role for the organizational hierarchy. Within Polaroid, there was a contrast between top managers' cognitive inertia and digital-imaging managers' rejection of a software-centered view for their emerging business. This contrast suggests that thinking and interpreting feedback from action can be situated, or not neutral to an agent's position in the organizational hierarchy. Both cognition and its situated nature highlight the importance of studying the interplay between "cognitions" differently situated in the hierarchy, as well as how it affects capabilities. For instance, at Polaroid, top managers ignored cognition at lower levels and decided which beliefs should guide search in digital imaging, with a significant negative effect on the capabilities developed.<sup>4</sup>

Polaroid's top-down arrangement is only one of many possible regimes of corporate influence. A simulation model can capture the gist of alternative regimes and study their properties in terms of capability formation. Rather than attempting to focus on all imaginable regimes, I consider three prominent archetypes (Greenwood and Hinings 1993, Siggelkow and Rivkin 2004) of organizational forms that recur in prior typologies of design. My development of archetypes is similar to that of Siggelkow and Rivkin (2004), who consider the allocation of decision rights within organizations, although I interpret this allocation with regard to cognition. I also consider a less-studied, but nonetheless plausible, regime that I call circulation of cognition. In sum, I consider four regimes:

(1) *Cognitive control*. This regime closely approximates Polaroid's top-down arrangement. In this fully centralized regime, corporate executives maintain control over the strategic orientation of the different domains in which the corporation competes. That is, their beliefs about how to do business set up specific premises (Simon 1976, Ocasio 1997) that guide search efforts carried out by lower-level actors operating within

divisional domains. This top-down imposition of cognition characterized decision making at many large U.S. firms during the early twentieth century (Chandler 1962, pp. 40–41).

(2) *Autonomy*. The autonomy regime, the mirror image of the cognitive control regime, approximates the multidivisional form (or M-form) as discussed by Chandler (1962) and Williamson (1970). It reflects the possibility that when a firm owns diverse businesses, senior managers are overwhelmed with too many decisions that require specific knowledge about how the organization can succeed in these businesses. Accordingly, this regime unburdens top managers by giving business-unit managers the latitude to independently model their unit's business landscape, develop a strategy, and execute it. Since the pioneering experiments of firms such as DuPont, most large U.S. multibusiness firms have adopted the M-form (Rumelt 1974, Fligstein 1985).

(3) *Coordination*. This regime suggests that sometimes there are valuable interrelationships between divisions, such as resource sharing or skill transfer (Porter 1985), which cannot be achieved unless corporate-level managers intervene in business units' affairs. Even when it is in a firm's interest for two divisions to capitalize on these interrelationships, divisional managers might be unwilling to engage in this activity because they believe doing so could reduce their units' profitability, or simply because their attention is focused strictly on their own unit's affairs. This tension is common to multidivisional firms, especially those with businesses in closely related industries or adjacent parts of the value chain (Poppo 2003). Because senior managers consider the whole firm rather than a specific division (Simon and Dearborn 1958, Williamson 1970), they can see interdependencies better than lower-level actors can. Polaroid's senior managers believed that all of Polaroid's businesses should use the razor/blade model and, thus, might have thought resource sharing between instant photography and digital imaging was justified.

(4) *Circulation of cognition*. This regime proposes that a firm's senior managers can "circulate" strategic wisdom from more successful businesses to a less successful one if the latter's performance is not adequate. In highly diversified firms, especially those that use strong financial controls to decide how to allocate resources, business units are often free to pursue a variety of strategies (Goold et al. 1994). Badly performing units may raise corporate actors' attention, which is highly constrained (Simon 1976, Ocasio 1997) and typically focused on solutions they find within their firm (Bower and Doz 1979). Therefore, circulation of strategic wisdom is a plausible response to weak performance.

The model of search I develop compares these regimes of influence, their adaptive properties, and their effects on capability development in different environmental conditions. For Polaroid, digital imaging was a radically

different strategic problem, and the potential for scope economies between its two divisions appears to have been weak. Because these two variables are useful for analyzing the relative power of the archetypes I consider, my model studies the properties of these regimes under distinct assumptions about the degree of similarity in the strategic problems the two businesses face and the strength of the tangible interactions across them.

More specifically, the simulation analysis unfolds in two phases. Firms first operate in a single line of business. My modeled managers reason on the basis of simplified cognitive representations of their decision problem leading to the choice of strategic beliefs. In turn, these beliefs guide the accumulation of experience or capabilities through local search. In the second phase, firms continue to operate in their original business, but also expand into a second line of business. In the new domain, firms first explore the new business and use this experience to choose a new representation for the novel problem, which underlies the development of new strategic beliefs. The particular regime of corporate influence adopted determines *how* the firm chooses the strategic beliefs that guide its search in the new domain. The simulation examines the regimes' adaptive properties in four different settings, which I obtain by considering different degrees of homogeneity (low and high) between the problem spaces the two divisions face and the potential payoff (low and high) for sharing activities (e.g., tangible interrelationships) across divisions.

This agenda poses several modeling challenges, which I address in the next section. The first entails modeling the strategic *problem/s* that organizations face. The second is the modeling of *search* processes. This task requires the formalization of: (i) cognition at multiple levels of the organizational hierarchy, which in turn requires modeling the cognitive representations that managers adopt to develop strategic beliefs, the thought processes leading to these beliefs, and the choice of representation for the strategic problem faced in the second phase of the simulated histories; (ii) the regimes of "corporate influence;" and (iii) local search, and how it relates to managers' strategic beliefs.

## The Model

The number and nature of features this model needs to incorporate make an algebraic approach impossible. Additionally, characterizing the dynamics of the model (e.g., search processes over time), can be extremely difficult with analytical, closed-form models, which typically emphasize equilibrium outcomes. I therefore adopt a simulation approach.

Among various possible simulation approaches to issues of search and adaptation (see, among others, Herriott et al. 1985, Lounamaa and March 1987, Lant 1994), numerous models of search have used the NK

simulation approach pioneered by Kauffman (1993) in evolutionary biology.<sup>5</sup> My simulation approach is an extension of Kauffman's original model. To put it simply, search is worth studying as a phenomenon, particularly if the complexity of the decision problem outstrips the bounds of managerial rationality: In a world of perfect rationality, the optimal solution would be immediately obtained independently of the specific search mechanism adopted. Following Simon (1962), a given problem is complex if it is comprised of numerous elements that substantially interact with each other. NK models offer a formal representation of the decision problem that maps directly to this conceptualization of complexity. They are thus a particularly appropriate starting point for studying search behavior under conditions of complexity. Indeed, adaptations of the NK framework have been demonstrated to be flexible platforms for studying cognition within organizations and its interplay with action-centered search mechanisms, an important property for the purposes of this paper (Gavetti and Levinthal 2000, Ghemawat and Levinthal 2000, Gavetti et al. 2005).

## The Problem Space

*Single Division.* A firm's decision problem can be conceived as the mapping from its decisions and payoffs. This mapping creates a payoff or fitness landscape in the space of decisions. Critical to this mapping is the degree to which alternative choices are interdependent. In their canonical specification, NK models are agnostic about the nature of interdependencies, which are assumed to occur at random. This assumption is at odds with the empirical evidence (Baldwin and Clark 2000), which supports the thesis that complex problems tend to have a nearly decomposable structure (Simon 1962). In Simon's words (1962, p. 193), "complex systems consist of a set of stable subsystems, each operating nearly independently of the detailed processes going on within the other subsystems, hence influenced mainly by the net inputs and outputs of the other subsystems." This notion informs the way I adapt the standard NK formal apparatus to model the problem space. Thus, in structuring the mapping between policy choices and payoff, I distinguish between "within-group" and "across-groups" interdependencies. In the context of organizations, we can think of these decompositions as, for instance, functional aggregations of policy variables.

In the model, three parameters— $N$ ,  $K_w$ , and  $K_a$ —determine the problem's structure.  $N$  controls the number of distinct policy choices in a business strategy context. For instance, Polaroid's senior managers chose to distribute digital cameras through mass retailers rather than through high-end photo shops; to develop and produce digital-imaging products internally rather than to partner with firms that had electronics expertise; and to

target the consumer market rather than high-end niches. I assume that the  $N$  policy choices cluster into  $S$  subgroups of  $N/S$  policy variables each. Each policy choice is a binary variable: it can take on two values, 0 or 1, and the payoff of a particular division is determined as the average of the payoff or the fitness contribution  $f_i$  of the  $N$  attributes it comprises.

$$F = \sum_{i=1}^N f_i \quad (1)$$

The parameters  $K_w$  and  $K_a$  govern the structure of interdependencies and determine how the payoff contribution of individual choices is obtained. They refer to the extent to which the payoff associated with one choice depends on other choices. The parameter  $K_w$  governs the degree of interaction *within* subgroups, while  $K_a$  affects the degree of interaction *across* subgroups. In particular,  $K_w$  indicates the number of policy variables within a subgroup that influence the fitness contribution of a given variable belonging to that subgroup. More precisely, a random number generated from the uniform distribution in  $[0, 1]$  is assigned to constitute the fitness contribution  $f_w$  of a given policy variable. Each policy variable can take on  $2^{K_w+1}$  different payoff values, depending on the combined resolution of the policy variable itself (either 0 or 1) and the  $K_w$  other variables with which it interacts. In worlds that are not fully decomposable, the mapping between choices and payoff is also affected by interdependencies across subgroups. The degree of decomposability, which the parameter  $K_a$  controls, is modeled by treating subgroups as policy variables. That is, according to a majority rule, each subgroup can take on two possible values: 0 or 1.<sup>6</sup> A random number generated from the uniform distribution is assigned to constitute a given subgroup's fitness contribution  $f_a$ , which depends on the combined resolution of the subgroup itself and the other subgroups. In sum, the fitness contribution of a given policy variable  $f_i$  is calculated as the convex combination of  $f_w$  (or the "within contribution") and  $f_a$  (or the "across contribution") with  $K_a$  effectively controlling the degree of interconnectedness across subgroups, or decomposability of the problem:

$$f_i = (1 - K_a) \cdot f_{wi} + K_a \cdot f_{ai} \quad (2)$$

*From Single to Multiple Divisions.* After an initial period of activity in a single line of business, my modeled organizations continue to operate in their original domain, but also begin to operate a new line of business.<sup>7</sup> Therefore, their problem space is now the mapping from  $2 \cdot N$  choices to a payoff value, the overall performance of the corporation. To simplify matters, I assume that the "weight" of each division is the same, so the payoff of such an organization is calculated as the average of the payoff obtained in each individual

line of business. As previously mentioned, I am interested in two features of the corporate problem space: the strength of "tangible interrelationships," or economies of scope between the two divisions, and the heterogeneity between the strategic problems they face. Let us consider them in turn. Tangible interrelationships can be defined as opportunities for sharing specific activities among business units that "lead to competitive advantage if sharing lowers cost or enhances differentiation enough to exceed the costs of sharing" (Porter 1985), and they are modeled by adding a "premium" for sharing the activity and a penalty for not sharing it. A given activity is shared when the two divisions operate the same choice regarding the activity. In more detail, tangible interrelationships are governed by the parameters  $K_t$  and  $Int$ , with the former determining the number of tangible interrelationships and the latter their intensity (when a tangible interrelationship does not exist for a given activity,  $Int = 0$ ).  $K_t$  operates as follows. Suppose  $K_t = 1$ . In this case, one policy variable, say  $i$ , is selected at random to represent a firm's tangible interrelationship. Therefore, the sharing of variable  $i$  between Division 1 and Division 2 generates a "premium" for the organization. The payoff of  $i$  ( $i_1$  for business unit 1,  $i_2$  for business unit 2) is modeled as the three-way convex combination of the "within contribution" of  $i_1$  and  $i_2$ , the "across contribution," and the premium or penalty for sharing or not sharing the activity. More formally, we obtain:

$$f_i = f_{i1} + f_{i2} \quad (3)$$

where

$$f_{i1} = (1 - K_a - Int) \cdot f_{wi1} + K_a \cdot f_{ai1} + Int \cdot f_{ii} \quad (4)$$

and

$$f_{i2} = (1 - K_a - Int) \cdot f_{wi2} + K_a \cdot f_{ai2} + Int \cdot f_{ii} \quad (5)$$

$Int$  weights the impact on fitness of the premium or penalty, which is obtained as follows:

$$f_{ii} = (0.5 + \delta) \quad \text{when the two business units decide to share the activity,}$$

$$f_{ii} = (0.5 - \delta) \quad \text{when the two business units decide not to share the activity,}$$

where

$$\delta = \text{random number drawn from the uniform distribution in } [0, 1/2].$$

To model the degree of similarity between the divisional decision problems, I first "seed" the performance landscape of one division. Doing so involves assigning a performance level to all possible combinations of policy choices. As noted, each choice is associated with a "within" performance contribution  $f_{wi}$  (i.e.,  $f_{wi1}$  for

Division 1). To obtain the performance contribution of the same choice in the second division, I take the convex combination of  $f_{wi1}$  and a random number  $r$  drawn from the uniform distribution in  $[0, 1]$ . More formally, we obtain:

$$f_{wi2} = (1 - \gamma) \cdot f_{wi1} + \gamma \cdot r \quad (6)$$

where the parameter  $\gamma$  tunes the degree of similarity between problem spaces.

### Search: Cognitive and Experiential Bases of Choice.

Now that the linkage between choices and payoff—the fitness landscape—is specified, the question is how companies search, or “move” on such landscapes. Answering this question requires modeling cognitive processes, how they are linked across levels, and how they relate to action or local search.

#### *Cognition on Fitness Landscapes.*

(A) *Representations and thinking (or “offline” search).* Most cognitive psychology characterizes cognition in terms of “representational structures in the mind and computational algorithms that operate on those structures” (Thagard 1996, p. 10). Individuals can neither envision all the alternatives available to them nor completely specify the causal linkages among possible alternative actions and their outcomes. Attempts to do so are limited by the many potentially relevant variables in a problem and the interrelationships among them. Thinking is thus often premised on cognitive representations of reality (Simon 1955), which simplify the decision problem in the mind of the agent (Johnson-Laird 1983, Weick 1990) and help her cope with her limited processing capacity (Halford et al. 1993)

Therefore, I assume that representations are a simplified mental model of the fitness landscape (Gavetti and Levinthal 2000). One way to capture this property is to assume that cognitive representations consist of broad categories, each capturing a portion of the underlying decision problem. More specifically, I assume that representations are comprised of  $N1$  categories, where  $N1 < N$ . To model the mapping between the categories of cognitive representations and the actual landscape, I also assume that although representations are simplifications, they are grounded on the landscape. More precisely, each of the  $N1$  categories in a representation can take on two values: 0 or 1. Therefore, the agent’s “cognitive space” (his or her mental image of reality) consists of  $2^{N1}$  points, each of which is assigned a fitness value equal to the average fitness value of the set of points in the actual fitness landscape that is consistent with this point. For a point in the  $N1$  dimensional space, there are  $2^{N-N1}$  points in the business unit’s actual landscape that are consistent with it.<sup>8</sup> If we consider the corporate landscape, there are  $2^{2(N-N1)}$  points consistent with an  $N1$ -dimensional representation. If representations at the

corporate level are more inclusive, they will necessarily be cruder than will those at the business-unit level because bounded rationality is equally constraining at all levels of the hierarchy and the problem space is more expansive for higher-level actors.<sup>9</sup>

Cognitive representations offer a small set of focal alternatives. In this context, thinking is the evaluation of the small set of alternatives that lie in managers’ “cognitive space,” what Gavetti and Levinthal (2000) dubbed “offline” search. Consistent with experimental evidence (Camerer 1997), I assume that people can choose the alternative that, according to their representation, maximizes payoff. This choice can be considered a template or a strategy that provides broad direction for choice.

(B) *The choice of representation.* If thinking is premised on cognitive representations, it is important to consider how representations are chosen. Indeed, the “quality” of representations, or their accuracy—the extent to which they capture the underlying decision problem—may vary dramatically. For instance, experts’ and novices’ representations of a problem differ. Chi et al. (1981) show that novices represent physics problems based on surface features, whereas experts ignore the surface features and categorize problems based on the physics principles associated with them. These experts do not have a larger category structure, but their structures are more accurate, and their problem-solving abilities benefit accordingly. Polaroid is a striking example of why it is important to adopt accurate representations. Although the cognitive representation underlying the razor/blade business model was appropriate for the traditional instant-imaging landscape, it was arguably a poor guide to managerial attention and choice in the digital-imaging domain.

Cognitive psychologists consider two key mechanisms for the formation of representations: inference and analogy. Pure inference can be powerful for incremental changes in individual cognitive models (Holland et al. 1986). It is not, however, particularly efficient for developing new representations to address novel problems, apparently because individuals have tremendous difficulty perceiving covariation accurately (Peterson and Beach 1967). The pervasive role of analogies as drivers for the development of beliefs in novel environments is typically related to this difficulty (Thagard 1996, Gavetti et al. 2005). Analogy entails the transfer of knowledge structures that were successful in one situation to another (Gick and Holyoak 1983) and does not require the *ex novo creation* of a new representation. Individuals approach a new problem with a set of representations they have directly or vicariously experienced, or a “cognitive memory,” and adopt what they believe is the most appropriate one for the new context. Inference might help them assess the appropriateness of different representations.

My operationalization of the choice of representation follows this line of argument. Actors do not create new representations, but select among ones they store in their memory; inferences help them do so. More precisely, I first endow actors both at the corporate and the business-unit level with a “cognitive memory” (i.e., with a set of  $M$  different representations, which correspond to different levels of accuracy).<sup>10</sup> Then, when facing the new problem (e.g., how to compete in a new line of business), organizations explore for  $P$  periods. They move one step at a time (i.e., they take one decision at a time), which results in a particular payoff. Actors observe these payoffs and use their early observations to infer which representation is the most accurate. In this context, accuracy is defined in terms of predictive power, or the discrepancy between the payoff a representation predicts for a given set of choices and the actual payoff for that set. The representation that, according to the actor’s evaluation, has the highest predictive power is adopted.<sup>11</sup>

*Regimes of Corporate Influence* Above, I discussed alternative regimes of influence (i.e., ways that cognitive processes occurring at multiple hierarchical levels might interact). In the model, such interactions come into play in the second phase of the narrative, when the company begins exploring its new strategic problem. The operationalization of the regimes of influence follows the description I offered. In particular:

(1) *Cognitive control*. Corporate executives choose a representation for the emerging business, develop strategic prescriptions on its premise, and impose it on the new business unit. Divisional managers have no choice but to accept these prescriptions, which become the basis for the local search that the new business unit carries out (see next subsection for a detailed discussion of local search).

(2) *Autonomy*. Lower-level agents can independently choose a representation of their unit’s strategic landscape, develop a strategy based on it, and execute the strategy through local search.

(3) *Pure coordination*. In this case, corporate executives focus attention on only a subset of policy choices and develop specific prescriptions for them. These prescriptions constrain local search in the new business unit and can trigger changes in the choices made in the original business. For instance, managers might think that the emergence of digital imaging makes it convenient to adopt a new and “shared” approach to marketing. In particular, I assume that, as boundedly rational actors, they focus on the subset  $T_i$  of the existing  $K_i$  tangible interrelationships and that they have no a priori intelligence of the potential gains associated with them: ex ante, managers cannot distinguish between weak and strong tangible interrelationships.<sup>12</sup> Apart from these constraints, divisional managers are autonomous in how they frame

the strategic problem, decide a strategy, and “flesh it out” through local search.

(4) *Circulation of cognition*. In this hybrid form, the new business unit behaves according to the autonomy regime for the first  $C$  periods of its life. During this period, corporate executives form expectations for the performance of the new business unit that are based on the initial performance in the original business. If the new business unit performs below their expectations for the entire period, they overrule business-unit managers by “circulating” to the new business unit strategic wisdom that was successful in the original domain (one could refine this operationalization and tune the degree of sensitivity of corporate managers’ decision to performance differentials by requiring that the performance gap in each period be higher than a given threshold. For simplicity, I consider only the baseline case.). Once a strategy has been decided, the new division autonomously engages in local search that is guided by these strategic prescriptions.

*Translating Cognition into Behavior*. A strategy premised on a given representation does not fully characterize behavior. For instance, Polaroid’s razor/blade business model does not fully specify the actions that should be taken with respect to either the kind of research and development to be undertaken or the particular production techniques to be adopted. It does, however, offer guidance regarding these and other choices. Therefore, a strategy or a business model may be considered a broad template or outline of possible actions: Once a new strategy has been decided, an organization fleshes out this template by modifying its current practices to make them consistent with this template (Gavetti and Levinthal 2000). After an initial, possibly disruptive, effect on current practices, new strategies become the basis for experiential learning (March and Simon 1958), or convergence (Tushman and Romanelli 1985), in which organizations fine-tune their routines under the broad constraints imposed by their strategic orientation.

In the model, I operationalize the translation of cognition into behavior by initially seeding each division with a set of  $N$  randomly assigned default practices. Once the division decides on a strategy, it modifies some of its practices to satisfy the constraint imposed by the template. This new configuration is the starting point for experiential learning, which I assume is based on local search (Cyert and March 1963). I define local search as the experimentation of alternatives that vary by one of the  $N$  elements: A policy array is tried that varies by one attribute from the current choice—one of the  $N$  attributes is chosen at random and shifted from its state of one or zero. The new attribute is maintained if it increases performance; otherwise, the organization goes back to the previous choice. This learning is carried out within the strategy’s constraints.

## Simulation Analysis

This structure permits me to consider various “states of the world,” in which I tune both the degree of similarity and the strength of the tangible interrelationships across the divisional problem spaces. First, I consider a setting that resembles Polaroid’s situation when it moved to digital imaging: great heterogeneity across the divisions’ strategic problems and weak tangible interrelationships. I then study a context in which economies of scope across divisions are strong and the divisional problem spaces are still highly heterogeneous. Finally, I explore situations in which these spaces are similar and tangible interrelationships across divisions are first weak and then strong.

For each setting, I examine search behavior and performance for a population of organizations with distinct regimes of corporate influence operating on the same fitness landscape. In the first phase, managers are endowed with a cognitive representation that they use to choose strategic beliefs, which in turn guide local search for the rest of the first phase. Organizations then move to a second line of business and explore it for some time. At the end of the initial exploratory period, managers at different levels of the hierarchy choose a cognitive representation based on the feedback obtained during these early “movements” over the landscape. They select one of the cognitive representations that they store in their “cognitive memory” and develop strategic beliefs based on it. The regime of influence that an organization adopts determines what beliefs guide search in the new domain. At this stage, the new business units modify their practices to conform to these broad beliefs before engaging in local search for the remaining periods of their lives.

### Setup and Parameterization

To ensure that the simulations reflect the model’s structure rather than particular realizations of a stochastic process, my results are based on the average behavior over 500 independent runs of the simulation model. The total length of each run is set at 45 periods (15 periods for the first phase; 5 periods for the exploratory period ( $P = 5$ ); 25 periods for the second phase). For each run, a distinct landscape is randomly specified. Each landscape has the same structure in terms of  $N$  ( $N = 9$ ),  $S$  ( $S = 3$ ),  $K_a$  ( $K_a = 0.5$ ), and  $K_w$  ( $K_w = 2$ ), but is seeded independently. Managers differently situated in the hierarchy have identical cognitive memories. Each memory contains three distinct representations ( $M = 3$ ), which are ranked in terms of how accurately they capture the new problem. Representations comprise  $N1 = 3$  categories. I subjected these structural parameters to a careful sensitivity analysis. According to this analysis, the results presented here are robust to a wide range of parameters.

In each analysis, the total number of organizations is 100, with 25 organizations within each subpopulation. The only difference among subpopulations is the

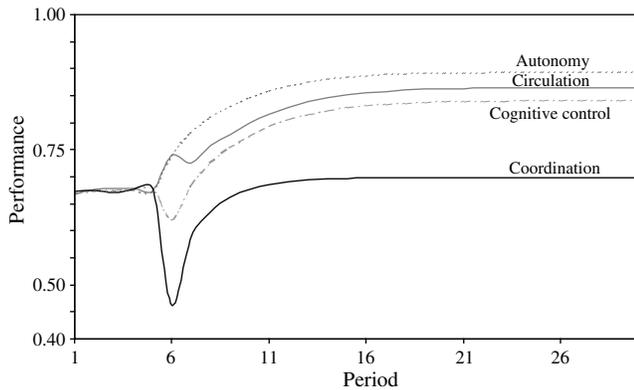
regime of corporate influence. Organizations adopting a coordination regime focus on  $T_i = 3$  potential tangible interrelationships. For organizations that adopt a circulation regime,  $C$  is set to 1 (it can be shown that results are robust to modifications in the length of  $C$ ). The 100 organizations are randomly seeded so that each is assigned a random location within the fitness landscape at the beginning of the simulation.

### Analysis

During the first phase of the simulated history, the search behavior and performance of my modeled organizations are invariant across subpopulations and states of the world. In this phase, the hierarchical aspects of cognition are dormant: The organization faces a single strategic problem, and managers at both levels of the organization thus focus on the same problem. Because they are endowed with the same cognitive representation, they also develop the same set of strategic beliefs. To better understand the search behavior of this population, I compare it with a subpopulation of organizations that engages only in local search. Immediately after the initialization, the adaptive performance of the population of interest is considerably enhanced by the intelligence of cognition, which quickly “positions” a firm in an area of the landscape that is superior to a randomly specified initial location. Furthermore, although most subsequent performance improvement stems from the accumulation of experience through local search, cognition persistently affects performance. In fact, the asymptotic performance of pure local search remains below the performance level of the population of interest.<sup>13</sup> If we interpret the accumulation of experience through local search as a process that leads to a “capability” (Winter 2000), this analysis suggests that cognition is central to capability development. More technically, the points that lead to the same local peak through local search belong to a “basin of attraction,” the size of which is positively correlated to the height of the peak with which it is associated (Kauffman 1993). The intelligence of local search stems from exploiting this property of basins of attraction: Despite the random seeding of organizations in the fitness landscape, the positive correlation between the height of a given peak and the size of its basin of attraction makes it likely that organizations searching locally end up on a peak that is higher than the average peak (Levinthal 1997). Cognition supplements local search by helping organizations to identify, on average, better basins of attractions, and therefore to develop better capabilities.

Figure 2 indicates the four subpopulations’ average performance in the model’s second phase for a setting of low homogeneity and low tangible interrelationships. Not surprisingly, during the first  $P = 5$  periods, corporate-level performance is flat and considerably lower than it is in the last periods of the previous phase.

**Figure 2 Heterogeneous Worlds ( $\gamma = 0.9$ ) and Weak Tangible Interrelationships ( $Int = 0.1; K_t = 5$ )\***

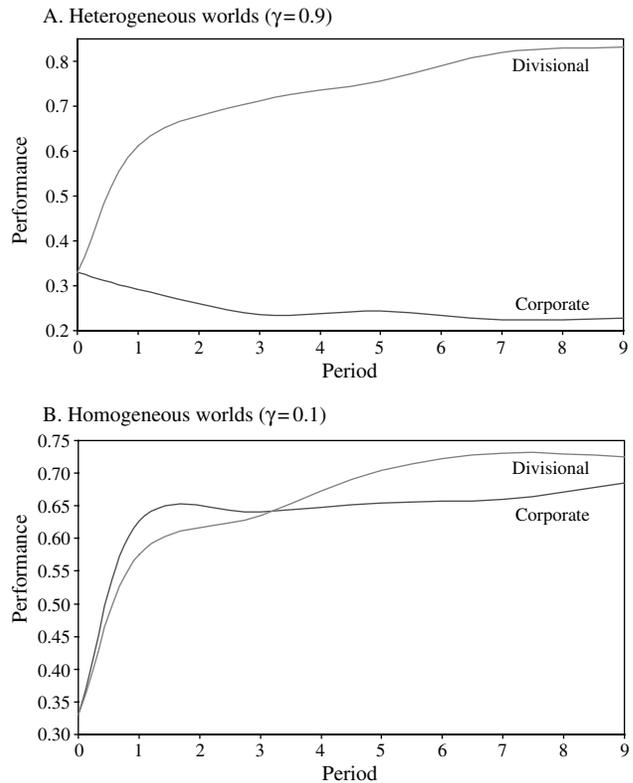


\*Average ratios of standard deviation to mean fitness value are 0.073 for cognitive control; 0.11 for coordination; 0.096 for autonomy; 0.096 for circulation.

Organizations still search the original landscape, but their performance improvement is negligible: They have either already reached a local peak (a local optimum) or are close to it, yet they also blindly explore the new landscape. Although this exploration is costly in the short term, it provides information that organizations use to choose a representation for the new business.

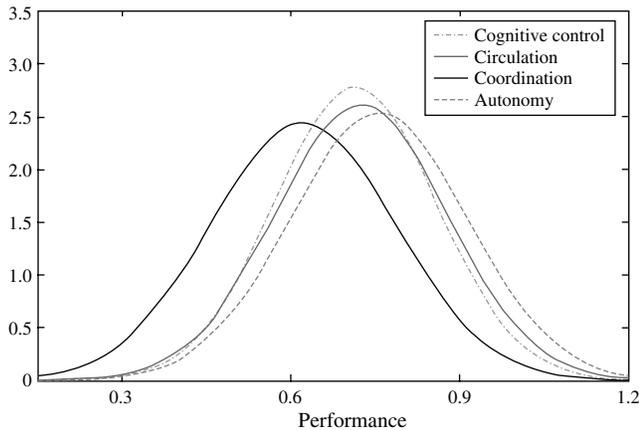
As we move past the exploratory period, it is interesting to contrast the two polar regimes of cognitive control and autonomy. As Figure 2 shows, when divisions face heterogeneous problems, the average organization adopting the “autonomy” regime performs considerably better than its counterpart under the “cognitive control” regime does. Because this gap manifests itself right after the choice of representation, it must be caused by differences in the effectiveness of the inferences informing this choice. Indeed, at the end of the exploratory period, lower-level actors in the “autonomy” regime choose the most accurate representation approximately 70% of the time, and corporate executives in the “cognitive control” regime do so less than 30% of the time. Figure 3A shows results from a companion analysis that studies how the effectiveness of the inferential process (percentage of “right” choices) varies across hierarchical levels for different values of  $P$  (length of the exploratory period) when divisions face heterogeneous problems. Because my modeled managers consider three alternative representations, when  $P = 0$  (no information), the most accurate representation is chosen 33% of the time. As the length of the exploratory period, and, therefore, the amount of information supporting the choice of representation, increases, so does the effectiveness of divisional managers’ inferences. In contrast, corporate executives are apparently misled by the information they pay attention to (i.e., aggregate data for multiple business units). An increase in the amount of such information reinforces this confounding effect, thus decreasing

**Figure 3 Inferences and Hierarchy**



the quality of their inferences. Corporate managers are misled because of their selective perception (Dearborn and Simon 1958): They tend to focus their attention on problems, actions, and outcomes that reflect their role within the firm.<sup>14</sup> Therefore, while business-unit managers concentrate on divisional problems, the cognition of corporate executives spans the multiple units that make up the organization.

Consequently, in the model, divisional managers directly observe the outcomes of an action their unit performs, and their evaluation of these signals is independent of what goes on elsewhere in the company. In contrast, corporate executives are concerned with the whole corporation and pay attention to more aggregate performance measures. They focus on corporate-level signals that aggregate information originating in both the old and the new domain. Interestingly, although these two information bases are assumed to be equally informative in the inferential process (corporate-level signals are operationalized by averaging the performance of the two individual businesses), it appears that a systematic bias favors signals originating in the old domain: Instead of choosing representations that accurately capture the target domain, corporate actors tend to select representations that fit the original business well. For instance, while Figure 4 shows that, when  $P = 9$ , the most accurate representation is chosen 23% of the time, it can be shown that, in this same analysis and when  $P = 9$ ,

**Figure 4** Payoff Dispersion—Period 8 [Heterogeneous Worlds and Weak Tangible Interrelationships]

corporate actors choose the representation that most accurately captures the original business 60% of the time. In other words, signals originating in the old domain appear to outweigh signals originating in the new one: Being close to a peak or in the neighborhood of an equilibrium point provides a stronger signal than lying in a valley does. Indeed, signals originating in the exploratory phase in the new domain are barely distinguishable from each other. On average, they gravitate around the mean value of the fitness landscape. Therefore, they are less “distinctive” and provide weaker evidence about the nature of the underlying decision problem relative to points that are close to a peak. Importantly, this bias does not reflect ad hoc assumptions about the inferential process because signals from the old and new domains are equally credible; instead, the bias is endogenous to the signals’ nature.<sup>15</sup>

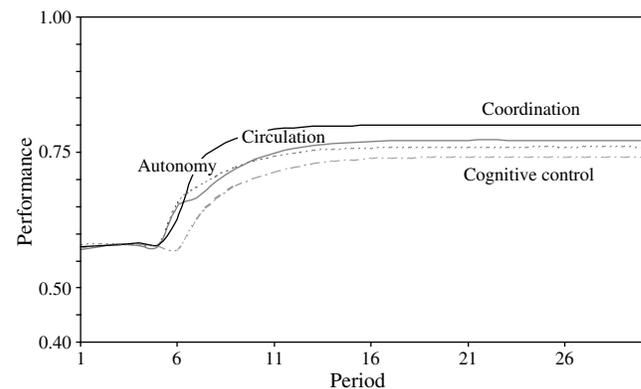
Figure 2 also suggests that circulating strategic wisdom in this setting may lead to less effective outcomes than “autonomy” does. Based on their previous experience in the original domain, corporate executives have performance expectations for the early phases of the new business’s life. If the new business is not as successful as they expect it to be, they transfer strategic wisdom from the old domain. Although the initial poor performance in the target domain may well be caused by maladaptive beliefs, replacing those beliefs by circulating old strategic wisdom does not appear to improve performance: The usefulness of strategic prescriptions is highly sensitive to the nature of the problem faced.

Finally, in this setting the “coordination” regime is the least effective of the regimes considered. Although each business unit in this subpopulation has autonomy to select a strategy, the performance gap between these organizations and the “autonomy” group is considerable, suggesting that the cost of pursuing ill-chosen tangible interrelationships can be high (Porter 1985). That is, pursuing economies of scope affects performance both directly and indirectly. The direct effect

comes from the benefit of sharing activities, while the indirect effect stems from the constraints that sharing imposes on business units’ choices. When economies of scope are weak, the indirect effects may be stronger than the direct effects are, thus lowering overall firm performance. The drop in performance following the experimentation period and the subsequent inability to reach the performance levels of the other subpopulations reflect this effect. Even if the new business unit adopts the most appropriate strategy, its search is constrained by the requirement to share activities with the other business unit. Furthermore, pursuing tangible interrelationships might involve changes in activities performed in the original domain that likely weaken performance in the absence of a significant benefit for sharing the activity.

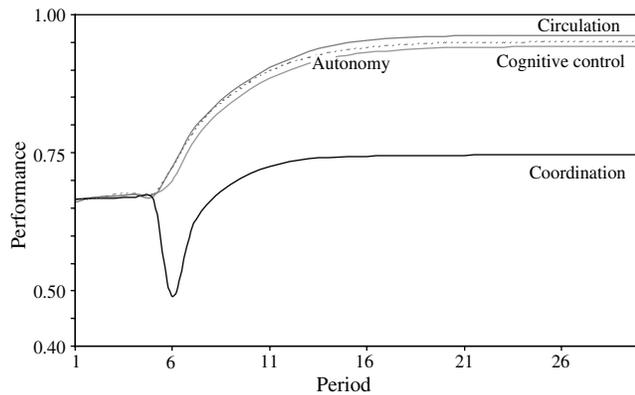
Figure 4 shows the probability density of payoffs for the four different types of simulated organizations after eight periods. As the figure shows, there is variation in outcomes, but the distribution of payoffs is roughly similar across organizations. This property holds true throughout the simulated history. What distinguishes regimes’ outcomes is their different mean. Pairwise comparisons across the four types of organizations considered show that the means are all statistically different from each other at the 1% level.

Figure 5 shows results obtained by replicating the previous experiment after an increase in the strength of tangible interrelationships. Although corporate agents are not fully cognizant of where strong tangible interrelationships exist, organizations that coordinate their business units’ activities exhibit the best performance. In contrast to the prior analysis, in which the “autonomy” group outperforms the “circulation of cognition” subpopulation, here the groups’ adaptive behavior is almost indistinguishable. By transferring strategic wisdom across divisions, corporate executives also indirectly homogenize behavior. In doing so, they help their

**Figure 5** Heterogeneous Worlds ( $\gamma = 0.9$ ) and Strong Tangible Interrelationships ( $Int = 0.45$ ;  $K_t = 5$ )<sup>\*</sup>

<sup>\*</sup>Average ratios of standard deviation to mean fitness value are 0.100 for cognitive control; 0.115 for coordination; 0.118 for autonomy; 0.117 for circulation.

**Figure 6 Homogeneous Worlds ( $\gamma = 0.1$ ) and Weak Tangible Interrelationships ( $Int = 0.1$ ;  $K_t = 5$ )\***



\*Average ratios of standard deviation to mean fitness value are 0.078 for cognitive control; 0.128 for coordination; 0.101 for autonomy; 0.100 for circulation.

organization exploit latent scope economies that are normally precluded when the business units are more autonomous.

In Figure 6, homogeneity is high across the two units' decision problems, and tangible interrelationships are weak. Although the poor performance of the "coordination" subgroup is not surprising, the behavior of the "autonomy" and "cognitive control" subpopulations deserves close attention. The latter subpopulation still underperforms the former one, but the performance gap between the two is now negligible and considerably lower than it is in the case I analyzed at the outset. Corporate actors' ability to infer from experience in novel domains depends on the degree of heterogeneity between these domains and the settings in which the company's history unfolded. Figure 3B reports results obtained by replicating the analysis reported in Figure 3A, but in a context of high homogeneity. These results are quite different. The effectiveness of corporate executives' inferences now approximates that of divisional managers. When  $P = 5$ , the length of the exploratory period chosen for all of the analyses, lower-level actors in the "autonomy" regime choose the most accurate representation approximately 70% of the time (as they did in Figure 3A), and corporate managers in the "cognitive control" regime do so 64% of the time (as opposed to less than 30% in Figure 3B).

Two causes explain the differences between Figures 3A and 3B. The first is in line with the rationale that I proposed to explain Figure 3A: Signals originating in the target domain tend to be outweighed by signals that originate in the old domain. Because the two domains in Figure 3B are now similar, signals' aggregation does not penalize corporate executives. Indeed, in the early phases of the exploratory process, their inferences are more effective than divisional managers'. The first signals processed by divisional managers have weaker information

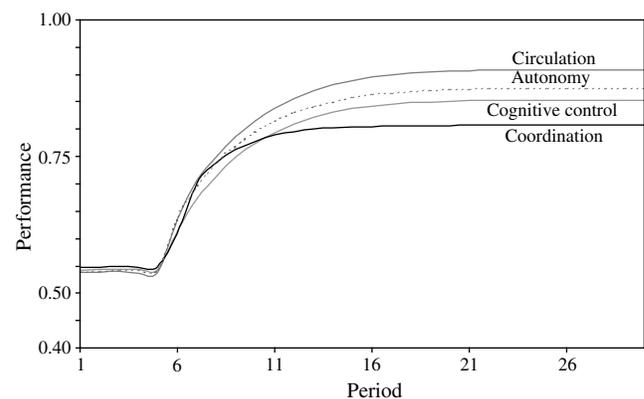
content and reveal the nature of the underlying decision problem to a lesser degree than signals originating in the old domain do. Thus, it takes longer for divisional managers to accumulate enough experience to make better inferences.

As divisional managers accumulate enough information, however, they outperform top managers. This behavior evidences a second effect. In the model, the choice of representation is based on the comparison between reality, a few bits of reality (what agents observe during the exploratory period), and different images of such reality that correspond to different ways of representing it. When corporate actors choose how to represent a new domain, they evaluate signals that reflect multiple realities. This more expansive focus of attention, which reflects corporate actors' greater "distance" from action, comes at the cost of missing some of the factors that determine the signals being considered. The effect is visible in Figure 3B. As divisional managers accumulate enough information, they perform better than corporate executives do, thus demonstrating the cost of relying on corporate-level signals. Because Figure 3B reflects similar realities or decision problems, the asymptotic distance between the two curves is modest. Conceivably, the aggregation of signals reflecting heterogeneous realities would be less neutral. Because these signals reflect different cause-effect relationships, drawing inferences based on their aggregation likely leads to superstitious outcomes.

Figure 6 also suggests, however, that corporate executives can improve overall firm performance by "circulating" strategic wisdom across divisions. As the two initial analyses suggest, the business units' landscapes must be similar for this regime to be really effective.

In the final setting, divisions share a similar problem space, and the tangible interrelationships across them are strong. Not surprisingly, as Figure 7 shows, top

**Figure 7 Homogeneous Worlds ( $\gamma = 0.1$ ) and Strong Tangible Interrelationships ( $Int = 0.45$ ;  $K_t = 5$ )\***



\*Average ratios of standard deviation to mean fitness value are 0.101 for cognitive control; 0.124 for coordination; 0.116 for autonomy; 0.111 for circulation.

**Table 1 Summary of Results**

Tangible interrelationships	Similarity	
	Low	High
Low	<i>Context I</i>	<i>Context II</i>
	I. Autonomy	I. Circulation
	II. Circulation	II. Autonomy
	III. Control	III. Control
High	IV. Coordination	IV. Coordination
	<i>Context III</i>	<i>Context IV</i>
	I. Coordination	I. Circulation
	II. Circulation	II. Autonomy
	III. Autonomy	III. Control
	IV. Control	IV. Coordination

executives add value by both circulating strategic wisdom and coordinating divisional activities.

The simulation analysis can be interpreted as generating testable hypotheses whose spirit is captured by Table 1. Table 1 ranks the different regimes in terms of their asymptotic performance levels in the four states of the world considered. These rankings obscure differences in the magnitude of regimes' performance differentials. In particular, although "Context II" and "Context IV" present the same ranking, the regimes' performance gaps are considerably more marked in Context II. However, the table still usefully summarizes the types of predictions that are amenable to empirical analysis.

### Implications and Conclusion

The premise of the paper is that research on capabilities needs microfoundations that capture more fully what we know about cognition and action within organizations. Motivated by this premise, this article offers three contributions. It derives a structure that extends current microfoundations of capability research, it specifies how this augmented structure contributes to our understanding of capabilities' evolution, and it sets an agenda for future research in this area.

At the most basic level, the paper uses a model of search to answer the question of *how* routine-based and cognitive logics of action can coexist within an organizational hierarchy to affect capabilities' evolution. The model's central tenet—that the aforementioned triplet needs to be considered jointly—echoes early writings in the Carnegie school (Simon 1976, March and Olsen 1976). However, most theoretical developments within this lineage have paid only modest attention to this need, as exemplified by evolutionary economics' behavioral foundations (Nelson and Winter 1982). The discipline imposed by my modeling efforts let me identify simple but plausible linkages among the triplet's components in a model of search that extends current characterizations of capabilities' dynamics. In fact, the model highlights

causal mechanisms that, although central to capability evolution, are missed by the "standard" microfoundational apparatus. Two such mechanisms stand out, and Polaroid's history helps illustrate them.

First, the model sheds light on cognition's role in capability development. My modeled managers think on the basis of simplified cognitive representations of their decision problem. This offline search underlies their choices of strategies, which in turn seed and constrain local search. In the simulations, managers' representations *imprint* the development of capabilities (Stinchcombe 1965, Burgelman 1988, Gavetti and Levinthal 2000): Higher-quality representations, which are chosen early on in the analysis, lead on average to higher-quality long-term performance or better capabilities. This role of cognition is illustrated by the Polaroid case. The "standard" view predicts it would have been difficult for Polaroid to develop new, leading-edge capabilities in digital imaging. This view suggests capabilities evolve slowly and locally because the search mechanisms underlying their evolution are local (Nelson and Winter 1982, 2002; Helfat 2000), yet Polaroid developed these capabilities early on, thereby overcoming these difficulties. Accounting for cognition's role sheds light on this apparent anomaly. The belief that success originates through technological breakthroughs directed Polaroid's search efforts toward digital imaging, and helped justify its massive investments, thereby contributing to overcome the limitations of local search. However, Polaroid destroyed these capabilities as the market for digital-imaging products emerged, and an important factor affecting these developments was the cognitive inertia of Polaroid's senior managers. Their belief in the razor/blade model helped move search in digital imaging away from the areas in which Polaroid excelled because of their inconsistency with this model. The general implication is that by complementing a logic of local search with a logic of cognition, different and more potent causal mechanisms arise that help explain capabilities' evolution. Importantly, continuity in a firm's capabilities might also be driven by factors other than the localness of routine development, with cognitive representations providing an intriguing parallel source of such continuity.

Second, given the aforementioned role of cognitive representations, how actors choose representations is integral to the causal structure of capability development. We thus need to understand how such choices are made. At Polaroid, this choice varied dramatically across hierarchical levels: Business-unit managers adopted novel beliefs for digital imaging, and corporate actors did not. My simulation examines one mechanism that might lead to such differences: information processing. In particular, by focusing on the effectiveness with which managers situated at different levels of the hierarchy interpret their company's experiences

in a new domain, it evinces two core properties. First, it suggests that the actor's distance from action diminishes her ability to interpret the firm's experiences. As she moves up in the hierarchy, action-outcome relationships become more blurred and more difficult to interpret. This effect is particularly strong when companies are engaged in multiple, heterogeneous domains, for which corporate managers, unlike divisional managers, have to assess different, potentially contrasting, action-outcome relationships. Second, more subtly, the analysis suggests that the information content of these signals may vary considerably. Specifically, it points to a positive relationship between the degree of adaptation a given action reflects and the informational power of the signals it generates: More "adapted" actions provide better information about the nature of the underlying decision problem than less adapted ones do. This asymmetry might complicate the interpretive efforts of corporate-level actors, particularly when they process information originating from multiple domains. If we conceive of multidivisional firms as ecologies of "unfolding experiences" that compete for managerial attention, this result seems to put the most novel "experiences" at a disadvantage. For instance, higher-level managers may devote limited attention to settings that appear ambiguous relative to settings where the organization is engaged. This behavior closely mirrors one tendency that Turner (1976) identified as an antecedent of organizational disasters: Because new information is ambiguous, managers tend to disregard early signals that could foreshadow punctuations in the organizational environment. Even when managers pay attention to ambiguous settings, they may perpetuate long-held, institutionalized beliefs, which are generally preserved when clear contradictory evidence is absent (Gouldner 1954). Alternatively, as in the model, higher-level actors may aggregate divisional signals, effectively letting the stronger signals prevail. In general, and independently of the mechanism, the asymmetry implied by this result suggests a "*paradox of newness*:" Novel domains, which, arguably, most need deliberate direction, are the most likely to have incorrect strategic beliefs chosen for them. When novelty is compounded by high degrees of heterogeneity, the likelihood of this event is even greater.

This more refined understanding of capability development's causal structure strongly suggests a central role for hierarchy and underlies our understanding of regimes' properties. Because the choice of representation imprints the development of capabilities, this choice is particularly relevant in the early phases of adaptation, when a firm enters a new market or when fundamental shocks change the structure of its strategic decision problem (Rumelt 1984, Zajac and Kraatz 1993). In these instances, the regime adopted is vital because it determines how representations are chosen and thus what strategic beliefs guide local search in the new context.

My analyses indicate that the effectiveness of different regimes depends on some aspects of the new strategic problems that organizations face, thereby suggesting an interaction effect between specific organizational and contextual characteristics. Follow-on empirical studies are in order to validate this interaction effect and associated predictions, as summarized in Table 1, and to provide a basis for understanding it better. Ideal contexts for these studies would preserve key properties of the context that inspired my model: a strategic problem that is new and distinct from other problem/s that other organizational unit/s face, and the creation of a new business unit operating in this new domain. Because organizational ecologists argue that authority structure is a core, inertial organizational attribute (Hannan and Freeman 1984, p. 156), one could consider various technological shocks corresponding to different positions within Table 1, and look for significant differences in the types of regimes that survive over a given time span. In this context, the use of event-history models to estimate how mortality hazard rates differ for divisions subjected to different regimes is theoretically appealing.

Finally, the paper suggests an agenda for future research. If more comprehensive behavioral foundations lead to a fuller understanding of capabilities' dynamics, work that uses routine-centered foundations risks overlooking relevant causal mechanisms. Because most empirical research on capabilities implicitly or explicitly espouses the routine-centered apparatus of evolutionary economics (Gavetti and Levinthal 2004), it is important to revisit established theories in the various domains in which this research operates. Work that I mentioned above on diversification (Rumelt 1974, Teece et al. 1994), knowledge management (Argote and Darr 2000, Szulanski 1996), technological change (Tushman and Anderson 1986), or entry (Klepper and Simons 2000, Klepper 2002) exemplify an approach to the respective phenomena of interest that draws more or less explicitly on routine-centered foundations. By using the behavioral foundations developed here, research in these and other domains could generate new insights into the phenomena under study. As I noted above, recent work has already started to develop this line of research. The current paper might accelerate this trend and inspire its further development. Relatedly, a better understanding of the causal mechanisms driving capabilities' evolution would benefit work on dynamic capabilities. Because much of this work rests on the behavioral foundations of evolutionary economics (Teece et al. 1997, Eisenhardt and Martin 2000, Winter 2003), the microfoundations articulated here would modify the very notion of dynamic capability. They would make cognitive inertia more relevant in defining the problems dynamic capabilities are to solve. Moreover, structural considerations that have been relatively neglected, like the role that is played by regimes

of influence, would become manifest as part of these problems' solutions.

At a different level, the project of microfoundational revision proposed and initiated here contains several limitations and corresponding opportunities for future work. First, in characterizing how representations change, the model privileges a fully cognitive interpretation of information processing at the expense of other considerations. For instance, it neglects the role of emotional attachment, which colors information processing (Simon 1976) and sometimes causes individuals to reject information that does not conform to the status quo (Thagard 2002). If emotional attachment was considered explicitly, it might reinforce the model's predictions. To the extent that emotional attachment to a given representation of the world is positively associated with tenure, higher-level managers might be systematically biased against or reject information that suggests the adoption of a new representation. Additional work should give due treatment to considerations that move beyond a purely cognitive interpretation of information processing. Second, my argument rests on a "passive" conception of cognition. In the model, managers are "modelers," not "shapers." They face a reality, build cognitive images of it, and act based on these images; they do not actively shape or construct their reality (Berger and Luckmann 1966). Although a constructionist approach is plausible, assessing the extent to which reality is given or enacted is a sufficiently important and complex issue that it merits separate treatment.

Despite its limitations, or perhaps because of them, the stylized conceptual apparatus that I put forth may tell us something new about how organizational capabilities originate and evolve. At the core of a large and growing body of research on capabilities is a routine-centered view of organizational behavior and search. Although I build on this idea, I also show the importance of accounting for cognition's and hierarchy's roles in capability development. Accepting this premise requires a different approach to capabilities that this paper begins to develop.

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### Endnotes

<sup>1</sup>Although an analysis of how the Carnegie school evolved is outside the scope of this paper, a few points are worth

emphasizing. In focusing on hierarchy, a central premise of Simon's *Administrative Behavior* (1976, see especially his discussion on pp. xxi and xxii) was that in studies of organizational decision making, questions about organizational structure cannot be decoupled from an understanding of individual executives' behavior and cognition. Although March and Simon (1958) paid less attention to hierarchical issues, they also focused on the behavioral bases of decision making in organizations, and explicitly recognized both calculative and routinized logics of choice and action (see especially their discussion on pp. 7–13, 2nd ed.). Yet, automatic, routine-based behavior, decoupled from cognition and hierarchy, assumed precedence in subsequent research, beginning with Cyert and March (1963), who noted that "Standard operating procedures are the memory of an organization and [since these procedures change slowly] it is possible to construct models that postulate only modest changes in decision rules" (p. 119). The need to recuperate the different dimensions of the aforementioned triplet has more recently been voiced by work within this tradition. For instance, Glynn et al. (1994, p. 45ff), note that the adaptive approach, which "views learning as the process of adjusting behavior in response to experience" (p. 46) has been favored over the knowledge development approach, which "focuses on the patterns of cognitive associations among context, structure, processes, and outcomes" (p. 49). Similarly, Ocasio (1997, p. 188) contends that the "effects of the social structure on the channeling and distribution of decision-makers attention have been greatly deemphasized if not lost" in research on attention and decision making.

<sup>2</sup>For extensive reviews of the capabilities literature, see Dosi et al. (2000) and contents therein, Helfat (2000) and contents therein, Nelson and Winter (2002), and Gavetti and Levinthal (2004).

<sup>3</sup>For a more nuanced perspective, see Carroll et al. (1996). Based on their study of the auto industry, they argue that entrants with preentry experience in related domains benefit from such experience in the early stages of the organization's life cycle. Later in the life of organizations, however, these factors become less important and likely create inertia relative to new organizations, which increases older firms' hazard rates.

<sup>4</sup>In focusing on the role of cognition and its situated nature, I do not wish to imply that other potentially relevant mechanisms also influenced Polaroid's outcomes. My only claim is that field-based and archival evidence suggests a relevant role for the mechanisms taken into account here.

<sup>5</sup>See, for instance, Levinthal (1997), Rivkin (2001), Ghemawat and Levinthal (2000), Gavetti and Levinthal (2000), and Siggelkow and Rivkin (2004) among many others.

<sup>6</sup>For instance, suppose that an organization is represented by the string of decisions ([1, 0, 0], [1, 1, 1], [0, 1, 0]), where the square brackets identify the  $S$  subgroups. In this case, the first subgroup takes on the value 0, the second 1, and the third 0.

<sup>7</sup>The model can be generalized to consider an indefinite number of divisions. For simplicity purposes, the case of two divisions is considered here.

<sup>8</sup>For instance, suppose that, as in Figure 4, the first category relates to the first three policy choices, the second one to policy choices 4 through 6, and the third one to the last three policy choices. The point in the agent's cognitive

space associated with the value  $[0, 0, 0]$  taken on by the three categories is the average of the real payoff values associated with choices that are consistent with it. For instance, the set of choices  $[000 | 000 | 000]$  is consistent with it, while the set of choices  $[110 | 000 | 000]$  is not. Indeed, according to a simple majority rule, when most of the choices associated with the first category are 1s, they are not considered consistent with the value 0 of the first category.

<sup>9</sup>This statement and the related operationalization of business-unit and corporate-level representations is contingent upon the assumption that business-unit managers focus attention on issues that strictly pertain to the domain of their business unit and that corporate executives focus attention on issues that pertain to the whole organization. This assumption is consistent with theories of selective perception, according to which executives, because of their bounded rationality, tend to focus on problems that strictly reflect their role within the firm (Dearborn and Simon 1958), and with more general theories about hierarchical systems (Barnard 1938, Simon 1969, Williamson 1970).

<sup>10</sup>In a set of preliminary analyses, I tested the accuracy of alternative representations for a given fitness landscape. The representations I considered varied with respect to the extent to which they reflected the underlying decomposition of the problem. In other words, I compared alternative category structures. Results show that accuracy varies substantially across representations. In particular, they show a positive relationship between, on the one hand, the degree of isomorphism between the agent's category structure and the decomposition of the problem and, on the other hand, the representation's accuracy.

<sup>11</sup>More technically, the nature of these inferences is operationalized as follows. In each of the  $P$  exploratory periods, the actor observes a performance level associated with a given configuration of policy variables. For this same configuration, each of the  $M$  representations would predict a different performance level. The predictive error of a given representation is calculated as the absolute value of the difference between the value it predicts and the performance observed over the  $P$  periods. The representation that is chosen has the minimum predictive error, or the maximum predictive power.

<sup>12</sup>In more detail, corporate executives are "assigned"  $T_i$  of the existing  $K_i$  tangible interrelationships at random, for which they develop strategic prescriptions. The thinking process leading to the choice of such prescriptions rests on a cognitive representation that is premised on the policy variables that managers consider relevant. The mechanics of thinking are identical to those described above. Here, however, representations are based not on broad categories but rather on the tangible interrelationships on which managers focus.

<sup>13</sup>In the current analysis and the following ones, I do not consider selection mechanisms. Considering these dynamics explicitly would reward early fitness advantages, thus accentuating the impact of cognition and its asymptotic effect. Less fit organizations (experiential searchers in this case) would be more likely to be selected out and replaced by replicas of the best performers (Wilson and Bossert 1971). The likely asymptotic effect of this selection process is the quasi extinction of pure local searchers.

<sup>14</sup>The model embeds the notion of selective perception. Although Dearborn's and Simon's original arguments on selective perception have been challenged (Walsh 1988), they enjoy

considerable empirical support (Ross and Sicoly 1979, Melone 1994).

<sup>15</sup>One could sensibly assume that new (and poorly distinguishable) signals are less credible and therefore less believed than old, highly reliable signals. In the model, I assume that they are equally credible.

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