29

Complexity Theory and Corporate Strategy

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INTRODUCTION

Corporate strategy focuses on the central strategic choices that are faced by multi-business firms with regard to creating competitive advantage and enhancing corporate performance. Multi-business firms are typically structured using multi-business-unit (BU) organization (sometimes termed M-form) in which the firm is divided into business-units (BUs) that are focused on particular product-market segments and yet also have some degree of interconnection with one another (e.g. shared human resource function, bundled products, or collaborative R&D projects), and are led by a corporate office (Chandler, 1991). The central strategic choices that form the substance of corporate strategy are typically considered to be: (1) motivation and control of the firm's BUs, (2) collaborations across BUs, and (3) firm scope. In this chapter, we present and contrast traditional perspectives on corporate strategy with a more recent view – a complexity perspective on corporate strategy – informed by theories of complex adaptive systems and with a growing body of empirical support.

Given the theoretical and practical importance of multi-business firms (Freeland, 1996; Galunic and Eisenhardt, 2001; Micklethwait and Wooldridge, 2003), the multi-BU organizational form has been examined from multiple theoretical perspectives, including information processing (Chandler, 1962; Galbraith, 1973), transaction cost economics (Williamson, 1975), and social network theories (Hansen, 1999; Hansen, 2002). These theories provide varied explanations for how the multi-BU organizational form generates value (Martin and Eisenhardt, 2010) such as by effective strategic decision making (Chandler, 1962; Galbraith, 1973), mitigation of opportunism (Berle and Means, 1932; Murmann and Frenken, 2006), and enhanced value creation through cross-business-unit collaboration (Helfat and Eisenhardt, 2004). While information processing, transaction cost economics, and social network theories offer important insights about corporate strategy, our purpose is to sketch corporate strategy from the alternative perspective of complexity theory.

The traditional theories of multi-BU organization, notably information processing

and transaction cost theories, take a corporate-centric perspective on corporate strategy. That is, corporate executives play the most critical role in corporate strategy by shaping the overall course of action and the broad architecture of BUs within firms. These theories also assume that corporate executives have the required information to make the central choices of corporate strategy and that they have the appropriate incentives such that they adopt the perspective of the entire firm (Chandler, 1962; Hill et al., 1992; Gupta and Govindarajan, 2000). In contrast, BU executives are assumed to have the most relevant knowledge for running their businesses, but also lack the vision and requisite information to identify collaborative synergies across the corporation and to set the scope of the firm. Moreover, particularly in the transaction cost economics formulation, BU executives are assumed to be likely to pursue self-interest that benefits them personally or benefits their BUs, but not necessarily the entire firm. To counteract this potential opportunism, corporate executives rely on incentives to align the interest of the BUs with the interests of the firm and on monitoring BU behaviors (Williamson, 1975; Hill et al., 1992). In addition, corporate executives are typically seen as responsible for orchestrating synergistic collaborations across the firm such as cross-BU collaborations on R&D projects, shared sales forces, and so forth. Corporate executives also set the horizontal and vertical scope of the firm. At the heart of these corporate-centric theories is an emphasis on efficiency as the driver of competitive advantage and superior performance in relatively stable markets.

In contrast, practitioners and scholars who view corporate strategy from the complexity perspective assume that the multi-BU organization is a complex adaptive system (CAS) consisting of modular, loosely linked, and unique BUs (Anderson, 1999). While this view of overall organizational structure is consistent with the well-known M-form, it differs from traditional information processing and transaction cost theories in its understanding of, and hence prescriptions for, the distribution of power and decision making, the roles of the various executive-actors and the management of important organizational processes for change. For example, when this approach is enacted the strategies of BUs emerge from the individual BUs such that BUs executives act relatively autonomously and loosely guided by simple rules that enable improvised action to adapt to real-time conditions (Eisenhardt and Sull, 2001); and a more decentralized distribution of power shapes cross-BU collaborations (Martin and Eisenhardt, 2010). Instead of corporate-driven, these collaborations emerge from the self-interested interactions of individual BUs. Moreover, while the extant theories of corporate strategy emphasize the design of structures and incentives, complexity theory emphasizes the processes (sometimes termed 'dynamic capabilities') that recombine the firm's resources and coevolve the firm with the environment (Eisenhardt and Martin, 2000). These processes include the *morphing* of the BUs in the context of simple rules to fit the environment (Eisenhardt and Sull, 2001; Rindova and Kotha, 2001), the *rewiring* of the collaborative connections among BUs (Martin and Eisenhardt, 2010), and the *patching* of the architecture of BUs within the firm by frequently adding, splitting, exiting and combining extant BUs (Galunic and Eisenhardt, 2001; Gilbert, 2006). Complexity theory thus calls for a fluid organization with multiple motors of adaptation that enable the firm to coevolve with changing environments. The key challenge for corporate strategy from a complexity point of view lies in finding the right balance of too much and too little structure. Too much structure is overly rigid while too little is too chaotic.

The purpose of this chapter is to outline corporate strategy from the perspective of complexity theory. Specifically, we apply the complexity perspective to the central strategic choices of corporate strategy, and compare the implications of complexity theory with those of traditional theories. We begin by sketching some key insights

from complexity science. We then examine multi-business organization as a CAS. We continue by describing how the central choices of corporate strategy unfold vis-à-vis the morphing of BU strategies using simple rules, rewiring of collaborations across-BUs to capture corporate synergies, and patching of the BU architecture that sets the scope of the firm. Overall, we highlight the emergent and process-driven character of corporate strategy, the unique roles played by different executives, and the critical points of comparison between complexity theory and extant perspectives.

ESSENTIALS OF COMPLEXITY THEORY

A major paradigm shift from a reductionist to a holistic perspective has taken place across scholarly disciplines. Since the 1600s, reductionism has been the dominant scientific method in Western theories with prominent adherents such as Descartes and Newton. For example, Descartes (2006: 17) aspired 'to divide all the difficulties under examination into as many parts as possible, and as many as were required to solve them in the best way'. As a result, large problems were broken down into simpler, constituent problems; and it was assumed that knowledge of a system's constituent parts would prove adequate for understanding the system as a whole. But while this decomposition had advantages, such pigeonholing often obscured understanding of the entire system with its emergent, 'complex' behavior (e.g. self-organization, nonlinear dynamics, and power-law distributions of system-level phenomena). Rather, understanding complex systems requires examination of their structural dynamics – i.e. constellations of elements which comprise the system, the connections and interactions among elements, their similarity, and their degrees of freedom.

Rooted in general systems theory and theories of nonlinear dynamical systems, complexity theory has been used across a variety of scholarly disciplines including biology (Kauffman, 1993, 1995, 2004), chemistry (Prigogine and Stengers, 1984; Bonchev and Rouvray, 2005), computer science (Holland, 1975, 1996, 1998; Simon, 1996), physics (Gell-Mann, 1994a; Bar-Yam, 1997; Gell-Mann and Tsallis, 2004; Ellis, 2005), entomology (Gordon, 1999), and economics (Arthur, 1989; Anderson et al., 1998). As concerns management, complexity theory has also been developed within organization theory (Simon, 1962; Anderson, 1999; McKelvey, 1999; Chiles et al., 2004) and applied to corporate strategy (Levinthal, 1997; Brown and Eisenhardt, 1998; Macintosh and Maclean, 1999; Rivkin, 2000). Across all of these fields, simulation studies have proved to be a powerful method for generating insights into whole-part relations and the phenomenon of complexity.

The term 'complexity' refers to a specific type of behavior that emerges from complex adaptive systems (CAS) (Holland and Miller, 1991; Gell-Mann, 1994a; Miller and Page, 2007), not to the system itself.[2] A CAS is comprised of partially connected agents whose interaction gives rise to the 'complex' behavior that is characteristic of these systems (Gell-Mann, 1994b). Within a CAS, each agent acts autonomously according to specific rules and in response to information received via connections to other nodes and in coevolution with the environment. The behavior of more-structured systems can be succinctly characterized by regularities produced by structures, which lead to ordered and predictable outcomes. The behavior of less-structured systems can also be briefly described by the well-defined property of randomness in mathematics. In contrast, in systems with moderate structure, the emergent behavior is an unpredictable combination of behaviors that are neither completely structured nor random, and so cannot be briefly described. Rather, they are 'complex' behaviors.

This transition phase between randomness and regularity is denoted as the 'edge of chaos' (Langton, 1990)[3] in which paradoxical and indeed "complex" behavior emerges. In the natural world, the edge of chaos is a transition point or zone, characterized by rich life forms and the emergence of complicated phenomena like the tidal area between sea and land, the transition zone at 32°F between water and ice, and the area around underwater heat vents. There exists a 'dissipative' equilibrium – i.e. it is an unstable such that the system is continually falling away from equilibrium. To maintain such an equilibrium, energy must constantly be injected into the system (Prigogine, 1984). A central focus of complexity theory is on the structures (e.g. rules, scale, formalization, and connections) which allow reaching and operating at the edge of chaos (Kauffman, 1995).

Two principal propositions are central to complexity theory. The first addresses the optimal amount of structure, and is rooted in the trade-off between efficiency and flexibility (Davis et al., 2009). It argues that partially connected systems of agents are higher performing than ones that are highly coupled or highly decoupled (Kauffman, 1995; Langton, 1990; Gell-Mann, 1994a). When the constitutive elements of the system are over-connected, the system becomes gridlocked and cannot adapt to new opportunities. At the extreme, it reaches a 'complexity catastrophe' in which the organization is able to address too few opportunities to succeed. In contrast, if the elements are under-connected, the system becomes too disorganized and error-prone to adapt. At the extreme, it reaches an 'error catastrophe' in which it lacks enough traction to capture enough opportunities. Thus, only partially connected systems (i.e. a moderate degree of structure) are both flexible and efficient.

The second proposition deals with the relationship between optimal structure and the environment. It argues that, as environmental unpredictability decreases, greater efficiency and so more structure become advantageous. In such environments, executives can develop structures that mirror patterns in the environment. In contrast, as environmental unpredictability increases, greater flexibility and so less structure are preferred (Davis et al., 2009). Moreover, since such limited structure is highly mistake-prone and attention-demanding, the range of optimal structures narrows to edge of chaos that is difficult to find and maintain. The optimal degree of structure (and the robustness of its range), therefore, depends upon the unpredictability of the environment (Eisenhardt and Sull, 2001).

ORGANIZATION AS A COMPLEX ADAPTIVE SYSTEM

A key premise of this chapter is that firms with the multi-BU organizational form are high-performing when they are managed and allowed to function as complex adaptive systems. Specifically, their BUs are unique 'agents' that are partially connected such as through common culture, consistent human resource practices, and discrete collaborations among BUs. When these connections are moderate, then the firm is likely to be high performing. Further, when environmental unpredictability increases, the optimal amount of structure (i.e. scale of business units, degree of formalization and centralization, and number of connections among agents) decreases.

Although the relevant empirical research within the organization theory and strategy literatures often does not explicitly use complexity theory *per se,* this research is nonetheless broadly consistent with the propositions of complexity theory. An example is Chandler's (1962) classic study of strategy and structure in diversified firms. This work describes how DuPont's centralized functional organization hindered its ability to adapt to rapidly evolving markets. DuPont went from being a single business firm prior to the First World War to operating

in diverse businesses in many markets in the post-War period. The company retained its centralized functional form and performed poorly. In reaction, its executives adopted multi-BU organization by structuring the firm into numerous, loosely linked and modular BUs. As Chandler (1962) relates, the firm became high-performing. In a contrasting case, Chandler (1962) indicates how Alfred Sloan brought together previously independent producers to form a set of loosely coupled, modular businesses that became General Motors. A key point is that, although these firms began from different starting points (i.e. over-structure at DuPont and under-structure at GM), both GM and DuPont became high-performing when they organized as complex adaptive systems.

Other research also supports the complexity theory proposition that firms with loosely coupled, modular BUs (i.e. complex adaptive systems) are high-performing. For example, Tripsas (1997) finds that firms in the typesetter industry with geographically dispersed R&D units were more high-performing than other firms. Their modular structures of loosely connected, but separate, 'agent' units spurred rapid innovation. These structures encouraged competition that was highly motivating, increased the variety of scientific approaches, and enabled working on overlapping technologies at different locations. In contrast, firms with more centralized and less modular structures lacked sufficient variety, i.e. requisite with that of their environment. Overall, the study confirms that firms with organizations that more closely resembled complex adaptive systems were more high-performing. Bradach (1997) provides another example. Examining five large US fast-food chains, he observes the benefits of two, unique store types within these successful firms – i.e. the simultaneous use of company-owned and franchised units. While company-owned units promoted efficiency with rapid deployment of innovations and uniform practices that ensured product and service consistency, the franchised units promoted flexibility by greater experimentation and innovation. By combining these two types of units, the firms balanced efficiency and flexibility to achieve high-performance.

Similarly, extant organizational theory and strategy literatures support the second complexity proposition that, when the environment is unpredictable, high-performing organizations are less structured. For example, this argument is well-supported in contingency theory studies that find organic structures to be high-performing when environments are volatile and mechanistic structures to be high performing in stable environments (Burns and Stalker, 1961; Davis et al., 2009). Another example is Gilbert (2005), who examines the organizing reactions of multiple newspapers to the environmental discontinuity that marked the emergence of the Internet. When addressing this disruptive nascent market, most newspapers retained the tight, structurally integrated organization that they had successfully used in their prior, stable environment. This monolithic organizing structure favored efficiency, and so proved to be inadequate in the unpredictable, Internet environment. Only those newspapers with executives who separated their established newspaper and Internet businesses into distinct and loosely coupled BUs were successful. Overall, the extant literatures provide support for the primary arguments of complexity theory – i.e. multi-business firms that are organized as complex adaptive systems are high-performing, and that their optimal amount of structure decreases with increasing environmental unpredictability. We turn now to consider the complexity perspective on the central choices of corporate strategy and its differences with traditional theoretical views.

MORPHING WITH A SIMPLE RULES STRATEGY

As described earlier, three strategic choices form the substance of corporate strategy. The first centers on how to *motivate and control*

BUs and their managers. The traditional view is based upon information processing theory (Chandler, 1962; Galbraith, 1973; Galbraith, 1974) and transaction cost economics (Williamson, 1975). Information processing proposes the division of responsibilities within the firm – i.e. corporate executives engage in high-level strategy, while the BU managers focus on the day-to-day operations of their business units and their BU strategy. Transaction cost economics adds the assumption that BU managers are likely to be opportunistic in their pursuit of self-interest. Therefore, corporate executives have the additional role of monitoring the performance of BU managers such that they instead seek the interests of the corporation. Alternatively, corporate executives control and motivate BU managers through 'high-powered' incentives which reward BU managers for the performance of their BUs and stand in contrast to 'low-powered' incentives which are based on the performance of the corporation. Overall, these theories emphasize that multi-BU organization is efficient through monitoring, incentives, and the rational partitioning of decision-making to the best-informed and motivated executives.

In contrast, complexity theory emphasizes the emergence of BU-level strategy from the improvisational actions of BU managers within the guidelines of simple rules. Improvisation enables firms to adapt to rapidly evolving markets with frequent strategic renewals (Agarwal and Helfat, 2009) that we term morphing. A prototypical exemplar is Hewlett Packard (HP). The firm started as an instruments company, but its BUs morphed the firm into a computer firm and then into printing by using a highly decentralized organization of loosely coupled, modular BUs and an improvisational process of adaptation driven at the BU-level as anticipated by complexity theory.

Central to the complexity theory perspective on managing BUs is the *'strategy of simple rules'* (Eisenhardt and Sull, 2001; Davis et al., 2009). Managing BUs consists of focusing on a few key processes and related simple rules that enable the improvisational capture of new opportunities at the BU-level (Bingham et al., 2007). In other words, complexity theory proposes simple rules to guide autonomously acting BUs such that each BU agent acts accordingly to some schemata (Rumelhart, 1984) or rules (Gell-Mann, 1995). These rules guide behavior in the absence of central coordination such that non-chaotic but 'complex' behavior emerges (Reynolds, 1987; Holland, 1996; Axelrod and Cohen, 1999). The result is that BUs morph in coevolution with the market.

A useful example of this morphing of BUs is described in the comparative case studies of Internet rivals, Excite and Yahoo!, between 1993 to 1998 (Rindova and Kotha, 2001). This early stage of the Internet was highly unpredictable, and so required firms to have some, but modest, structure. In particular, Yahoo executives focused on several processes including alliance formation and product development, and developed a few rules to loosely structure those processes to enable improvisation. For example, Yahoo's simple alliance rules included (1) no exclusive deals and (2) basic service is always free. Yet within these rules, BU managers at Yahoo had a significant flexibility to pursue a variety of unanticipated and often successful alliances. Overall, both firms (but especially Yahoo) used simple rules to morph from being search engines to being Internet destinations, and subsequently Internet portals.

Similarly, Brown and Eisenhardt (1997) focus on how the successful BUs of firms in the computing industry used a few rules within the product development process (e.g. responsibility assignments, priorities) to morph via frequent release of new products. As a result, these firms frequently renewed their product portfolios through improvisation. As one developer commented 'We fiddle right up until the very end' (p. 11). The resulting interplay of structure and improvised action gives rise to 'complex' behavior that is neither well-structured nor completely random (Gell-Mann, 1995). So much like a jazz band (Berliner, 1994;

Hatch and Weick, 1998), BUs morph (Miner et al., 2001).

A key difference between traditional theories of managing BUs and complexity theory is *executive roles*. From the complexity perspective, strategy is not centrally determined by corporate executives, but rather emerges from BUs. In other words, BU managers, who adapt their business activities to changing market within the context of moderate structure, create strategy. A telling example is Burgelman's (1994) study of Intel in which he examines the emergence of autonomous actions at low levels of the firm in Intel's exit from the DRAM business. The crucial behaviors were the reallocation of resources by mid-level managers who were following simple rules surrounding priorities for manufacturing capacity. This action changed the trade-off between the mature DRAM business and the nascent microprocessor business. The later decision to exit DRAMs by corporate executives was in fact *ex post* (Burgelman, 1994, 2002). Thus, while traditional theories emphasize incentives and monitoring to motivate and control potentially opportunistic BU managers, complexity theory emphasizes having the appropriate processes and the right rules (both content and number) in place such that BU managers can flexibly and efficiently morph their businesses in coevolution with their relevant environments.

Finally, recent research develops a richer understanding of the strategy of simple rules by examining more closely the nature of simple rules. In a multiple-case, inductive study, Bingham et al. (2009) examine the internationalization process of entrepreneurial firms to understand how portfolios of rules develop over time. They find that the relevant rules focus on capturing opportunities, and that rules for selecting and executing opportunities are learned first. Later, rules surrounding the priority, sequence, and timing of multiple opportunities are learned. Moreover, the authors find that executives consciously cycle through elaborating and then simplifying their rules to maintain moderate structures over time. That is, they 'underspecify' their portfolio of rules firms by engaging in 'simplification cycling'. Moreover, BU executives actively varied the level of abstractness of the deployed rules. Lower abstraction renders a rule concrete and sharply specified. For example, one BU replaced its opportunity selection rule from 'retail customers' to 'grocery customers' (lower abstraction). Conversely, higher abstraction renders a broader, more general rule that is more disassociated from particular instances. For example, one BU raised the abstraction of its selection rule from 'governments and banks' to 'large organizations with proprietary information and the ability to pay'. Recent research has analysed the processes how firms develop simple rules based on their process experience (Bingham and Eisenhardt, forthcoming). Overall, this work identifies the types of rules, their patterns of being learned, and their focus on effective opportunity capture such that BUs are able to morph. Table 29.1 summarizes key differences between traditional and complexity perspectives as concerns the motivation and control of BUs.

REWIRING CONNECTIONS AMONG BUSINESS-UNITS

A second strategic choice at the heart of corporate strategy is the identification and implementation of synergistic collaborations among BUs. The existence of synergies is a prime rationale for the existence of the multibusiness corporation (Panzar and Willig, 1981; Bailey and Friedlander, 1982; Teece, 1982; Milgrom and Roberts, 1990). The potential for synergies across businesses is often central to the strategic logic for firm-level moves such as diversification and acquisition (Goold et al., 1994; Graebner, 2004). Indeed, Bowman and Helfat (2001) have argued that cross-business collaborations are a significant source of value creation for the diversified corporation. Research has shown

Table 29.1 Motivation and control of business units (BUs)

	Traditional perspectives	*Complexity perspective*
Objective	Efficient alignment of BU actions with firm objectives	Effective morphing of BU in coevolution with market
Role of corporate executives	Monitor BU actions and reward BU managers with 'high-powered' incentives	Appoint high-quality BU managers and reward them with 'high-powered' incentives
Role of BU managers	Identify and execute business strategy	Identify and execute business strategy in accordance with corporate-wide simple rules, to morph their BU
Focus	Strategic content	Strategic content and moderate number of rules
Steps	Identify attractive markets Locate defensible position Fortify that position	Identify key processes with attractive opportunity flow Determine simple rules for capturing opportunities
Risk	BU managers will be too slow and rigid to change	BU managers will be too tentative in executing on promising opportunities

that the connections among BUs are a likely explanation for sustained inter-firm differences in profitability (Brown and Eisenhardt, 1997; Levinthal, 1997; Rivkin, 2000; Bowman and Helfat, 2001; Lenox et al., 2006). Yet despite its importance, the effective capture of synergistic value across BUs through collaborations has often proved challenging even for otherwise high-performing firms such as Johnson and Johnson (Hill and Hoskisson, 1987).

The traditional theoretical perspectives on cross-BU collaborations take a corporate-centric view. They emphasize that centralized identification of synergistic collaborative opportunities by corporate executives and implementation led by corporate executives, with firm-wide incentives for BU managers, are most likely to yield high-performing, cross-BU collaborations (Hill et al., 1992). These arguments rest on several assumptions. First, according to information processing theory, corporate executives have superior information about collaborative opportunities, and the appropriate authority to identify and implement the most promising cross-BU connections (Chandler, 1962, 1991; Sloan, 1963; Freeland, 1996; Gupta and Govindarajan, 2000). It is also assumed that potentially high-performing collaborative opportunities are well-formed and obvious to these corporate executives. Further, as argued by transaction cost economics, corporate executives have the appropriate firm-wide incentives for finding and leading cross-BU collaborations while BU managers who might otherwise pursue self-interest can be motivated to collaborate by firm-wide incentives (Williamson, 1975; Hill et al., 1992). Furthermore, corporate executives are assumed to be able to resolve conflicts among collaborating BUs (Boulding, 1964) and enforce the sharing of resources (Berg, 1973; Pitts, 1977). Indeed, from the perspectives of information processing theory and transaction cost economics, a primary responsibility of corporate executives is the development of cross-BU collaborations (Chandler, 1991; Collis and Montgomery, 2004).

In contrast, complexity theory takes a BU-centric view in which high-performing, synergistic collaborations across BUs emerge from the interactions among BU members engaging in their own self-interested actions (Martin and Eisenhardt, 2010). These collaborations often begin with serendipitous problems and opportunities rather than being explicitly pursued and planned. As a consequence, collaborations often start informally and at low organizational levels such as when low-level BU engineers realize that working together on

shared product components might be mutually beneficial. BU general managers and their organizations then develop these promising emergent collaborations by rewiring the firm's web of cross-BU connections through the formation of collaborations. Frequent 'rewiring' (Martin and Eisenhardt, 2010) allows the firms to coevolve with changing markets, target new growth opportunities, and generate innovation (Wuchty et al., 2007). A well-known example is Disney, a firm that frequently forms and disbands collaborations among diverse BUs including theme parks, TV channels, retail stores and movies (Eisenhardt and Galunic, 2000). The result is extensive synergistic value creation among Disney's various businesses including well-known collaborations around proprietary characters such as the Lion King as well as lesser-known collaborations that leverage competences throughout Disney such as managing restaurants.

An in-depth example of rewiring is the study of cross-BU collaborations within six software firms (Martin and Eisenhardt, 2010). Examining both a high- and low-performing collaboration in each firm, the authors find that serendipitously discovered collaborative opportunities by BU members are more likely to create high-performing cross-BU collaborations than planned collaborations identified by corporate executives. In this BU-centric view, collaborations among BUs are not preplanned, but emerge in reaction to opportunities such as collectively developing shared product components and problems such as scarce resources and competitive threat. For example, Martin and Eisenhardt quote one BU manager: 'It was really a groundswell. … They [engineers from the 2 BUs] just started meeting to solve the problem. It did not come from an executive [corporate] level where it's, "Thou shalt do it"'. Moreover, in contrast with traditional views, these collaborative opportunities are typically ill-defined such that it is not obvious *a priori* how or whether to pursue them. So BU members further develop promising collaborative opportunities through deliberate learning activities such as experimentation that involve customer focus groups or technological prototyping and deconstruction of past successes and failures in similar collaborations. This learning serves to clarify the value of the collaboration and how best to proceed as well as builds support for the collaboration among participating BUs. Martin and Eisenhardt (2010) also find that the ultimate decision to implement and the implementation approach rest with BU general managers. Thus, high-performing cross-BU collaborations are driven at the BU-level as anticipated by complexity theory, and enable BUs to recombine existent knowledge to generate innovations and growth (Hargadon and Sutton, 1997; Wuchty et al., 2007). In contrast, the authors find that a corporate centric approach is not effective. Rather, corporate executives lack detailed knowledge of the BUs, are overly confident of their own ability to spot high-performing collaborative opportunities (Roll, 1986; Hiller and Hambrick, 2005) and are too dismissive of the challenges that are posed by the implementation of collaborations (Freeland, 1996). Yet, given their authority within the firm, corporate executives can nonetheless impose collaborations on their firms.

A key difference between traditional theories of identifying and implementing synergistic cross-BU collaborations and the complexity view is *executive roles*. From the complexity theory view, collaborations emerge from BUs and are shaped by BU managers. Thus, collaborations are decentralized. But while corporate executives are not leading collaborations, they nonetheless set the stage for high-performance by facilitating their emergence and implantation. They do so by reducing the costs of identifying and transferring knowledge among BUs (Hansen, 1999), creating mutual trust and fostering informal relationships among BU managers (Tsai, 2000), and appointing high-quality BU managers in whom others will be confident. Thus, they may institute simple

approaches such as placing coffee bars in key office areas such that BU members have opportunities to meet serendipitously (Brown and Eisenhardt, 1997), or more complicated approaches such as fostering cross-BU career paths (O'Reilly III and Tushman, 2004: 79; Williams and Mitchell, 2004; Williams and Karim, 2008), allowing double-counting of collaboration-related revenues to participating BUs, and employing 'synergy managers' whose job consists of connecting BU members who might have common interests. Overall, the key point is that, while corporate executives do not effectively identify and implement collaborations across BUs, they can set the contexts that enhance the likelihood that useful collaborations will emerge and be successfully implemented.

A second key difference between traditional theories and complexity theory is the role of *incentives*. Transaction cost economics, in particular, emphasizes the importance of firm-wide incentives for BU managers to encourage their cooperation in cross-BU collaborations. The notion is that BU managers will not be motivated to cooperate unless their incentives are aligned with the fate of the entire firm. In contrast, complexity theory assumes that high-performing collaborations are motivated by the self-interested actions of the BU managers and so incentives based on BU performance encourage the formation of synergistic collaborations. Here the argument is that it is difficult and even impossible to identify the optimal, high-performing collaborations and so the best approach to identifying such optimal collaborations is to identify those collaborations that each involved BU sees as adding local, BU-level value. Thus, the complexity perspective contrasts with a collectivist culture where collaboration for the sake of collaboration is valued as well as with a top-down, centralized view (Eisenhardt and Galunic 2000). Further use of high-powered incentives based on BU performance is simple, and more effective than more complicated blends of high- and low-powered incentives (Wageman and Baker, 1997; Kretschmer and Puranam, 2008).

Finally, a particular interesting notion from the lens of complexity theory is that a *moderate number of cross-BU connections* is highest-performing with this optimal number declining with increasing environmental unpredictability (Davis et al., 2009). So while traditional views implicitly assume that more collaborative connections among BUs are more value-creating for the firm, complexity theory does not. Rather, fewer collaborations can be higher-performing when they focus the attention of BU managers on successfully executing the most promising collaborations while also ensuring that they attend to managing their BUs effectively. Thus, a moderate number of cross-BU connections renders the highest performance by balancing flexibility and efficiency. Indeed, over-connected BUs become gridlocked, and unable to morph. A good example is Vail Ski Resorts, a firm consisting of multiple ski destination resorts in the US. The firm was assembled through a series of acquisitions with the intent of driving synergistic value creation top-down across the resorts (Eisenhardt and Galunic, 2000). But the resulting over-connection reduced the individual uniqueness of the resorts and stifled their flexibility to adapt to their local environments. To repair the damage, executives eliminated numerous ties and set the conditions that enabled the emergence of new, more high-performing connections from the ski resorts themselves. Unexpectedly a lower number of collaborations created greater synergistic value among the BU-resorts than greater connection. The central point is the importance of focusing on only a moderate number of potentially high-performing collaborations rather than pursuing all possible collaborations as anticipated by complexity theory. Table 29.2 summarizes key differences between traditional and complexity perspectives as concerns the identification and execution of synergistic BU collaborations.

Table 29.2 Identification and execution of synergistic BU collaborations

	Traditional perspectives	*Complexity perspective*
Objective	Efficient cost synergies	Effective rewiring of BU connections in coevolution with markets
Role of corporate executives	Identify promising, well-defined collaborations, with fiat to execute given to BUs	Set the context in which cross-BU collaborations can emerge from BU-driven initiatives
Role of BU managers	Corporate driven: Execute cross-BU collaborations identified by corporate executives	BU driven: Lead deliberate learning to shape and vet promising, but ill-defined cross-BU collaborations, make decisions to collaborate with other BUs, and collectively execute
Focus	Content of synergistic collaborations	Content and number of synergistic collaborations
Steps	Corporate executives seek collaborative opportunities Corporate executives make decision to collaborate BU managers plan and execute	BU members serendipitously find collaborative opportunities BU members deliberately learn about the collaboration Multi-business team of BU managers decide to collaborate and execute
Risks	Poor collaborations are executed Good collaborations are poorly executed Too many collaborations executed	Optimal, firm-wide collaborations are neglected

PATCHING THE ARCHITECTURES OF BUSINESS-UNITS

A third strategic choice of corporate strategy centers on the determination of horizontal and vertical scope within the firm. From the perspective of traditional theories, the dominant logic for the scope of the firm is efficiency (Porter, 1980). Vertical scope, i.e. the decision to make or buy, is shaped by minimizing the transaction costs associated with small numbers bargaining and asset specificity (Williamson, 1975) and gaining the economies of scale associated with greater volume. Horizontal scope, i.e. the decision in which markets the firm is active, is shaped by the efficient sharing of resources across BUs (Teece, 1980). Thus, executives should expand the horizontal scope of the firm if there are opportunities to leverage existing resources. Overall, this perspective emphasizes efficiency and thus appropriate scope, but does not consider how firm executives structure their internal organization to achieve scope efficiencies or adjust that scope as environmental conditions shift.

In contrast, the complexity theory view focuses on the patching process by which executives frequently realign firm scope in coevolution with the environment (Eisenhardt and Brown, 1999). By patching we mean the process by which executives set the architecture of the firm and its scope by adding, eliminating, combining and splitting BUs, and transferring product-market charters among them. The notion is that the corporation is a complex adaptive system in which the patchwork or architecture of BUs is continually realigned with the environment via patching. Thus, the complexity theory view not only focuses on scope, but also on the internal architecture of the system of BUs. Moreover, as environments change, the BU architecture may become obsolete. Firms can correct these misfits by combining, splitting or adding BUs or reassigning an extant BU to a new product-market domain[4] (Galunic and Eisenhardt, 1996, 2001; Eisenhardt and

Brown, 1999). Thus, by patching, firms are able to target changing opportunities, create and recombine resources, and generate innovation (Macintosh and Maclean, 1999; Lichtenstein, 2000; Karim, 2009). A well-known example of patching is Dell Computers in which the firm reassesses its architecture of BUs on a quarterly basis for many years. Another exemplar is Hewlett Packard's (HP) where executives relied on patching to grow their instruments, computing, and printing businesses. To ensure focus, executives frequently rearranged BUs, lopping off pieces and transferring them to new and existing BUs (Eisenhardt and Brown, 1999). Overall, by engaging in patching (Ciborra, 1996; Levinthal and Warglien, 1999; Galunic and Eisenhardt, 2001), firm executives can create corporate value in a way that is uniquely available inside corporations and not easily replicated by the market.

Galunic and Eisenhardt (1996, 2001) examine the patching process within a particularly successful, technology-based firm by studying the frequent re-assignment of a product-market domains (or charters) to BUs. They find that executives within the firm (termed Omni by the authors) frequently revisit the match of BUs, their skills, and business opportunities with the environment, and realign them as appropriate. This generates competition for charters among BU that not only is beneficial for the BU-domain fit, but also increases the overall competitiveness, fit, and flexibility of the firm. Corporate executives act as referees of the BU competition, find safe BU 'homes' for orphaned charters and reinvigorate flagging BUs by assigning new charter opportunities to them.

There are several antecedent conditions that enable effective patching (Eisenhardt and Brown, 1999). First, the firm has to be organized such that BU modularity exists whereby the firm is broken into discrete, unique BU chunks (Schilling and Steensma, 2001; Langlois, 2002). Second, fine-grained comparable business metrics are needed to allow corporate executives to recognize general patterns in the environment, identify non-performing BUs, and facilitate the novel combination of extant BUs. Third, companywide compensation parity is important because it mitigates barriers to moving employees among BUs. These conditions facilitate the realignment of BUs and product-market charters that is at the heart of patching.

A key difference between traditional theories and the complexity theory view is *executive roles*. Prior theory emphasizes the corporate executives set firm scope based on efficiency criteria. But there is no substantive consideration of the process by which this occurs. In contrast, complexity theory emphasizes a more complicated political process involving corporate executives and BU managers who may be competing with one another for product-market opportunities. This process includes spotting opportunities, breaking up BUs that are too big for effective morphing, combining ones that are too small for scale efficiency, and refereeing by corporate executives among BUs that are competing for converging product-market opportunities. Consequently, a key skill of corporate executives is pattern recognition of the environment (Ciborra, 1996; Eisenhardt and Brown, 1999) that enables them to recognize trends in how markets evolve to develop corresponding products, services or technologies.

A second key difference is the critical importance of *BU scale*. While it is straightforward to recognize that firm scope and architecture should match distinctive BU competences with corresponding product-market opportunities, the complexity view uniquely emphasizes the importance of BU scale that fits with unpredictability of the relevant environments. This means smaller scale that favors flexibility in unpredictable environments and larger scale to favor efficiency in more predictable ones (Eisenhardt and Brown, 1999; Ethiraj and Levinthal, 2004). Small BUs allow the firm to adapt to market niches while large BUs have the advantages of economies of scale, lower coordination costs, and sufficient resources

Table 29.3 Determination of firm scope

	Traditional perspectives	*Complexity perspective*
Objective	Efficient firm scope	Effective patching of firm scope and BU architecture
Role of corporate executives	Determine and execute efficient external boundaries	Match patterns in evolving markets to internal and external boundaries
Role of BU managers	Operate BU within assigned product-market domain	Morph BUs in coevolution with product-market domain(s)
Focus	Content of firm scope	Content of firm scope as well as architecture and scale of BUs
Steps	Identify economies of scale and scope, and transaction costs Set external boundaries of the firm	Referee competition among BUs Fill market 'white spaces' Set internal and external boundaries of the firm
Risks	Misalignment of firm with markets Failure of major corporate reorganizations	Excessive competition among BUs

to pursue opportunities (Eisenhardt and Brown, 1999; Burgelman and Grove, 2007). The optimal scale occurs at the edge of chaos where executives balance efficient scale economies with flexible adaption in unpredictable markets. Table 29.3 summarizes key differences between traditional and complexity perspectives as concerns the determination of firm scope.

CONCLUSION

The purpose in this chapter is to understand corporate strategy from the perspective of complexity theory, and to contrast that understanding with traditional theories of corporate strategy. As noted earlier, complexity theory focuses on the fundamental tradeoff between efficiency and flexibility. So, finding a balance between too much structure and too little, and shifting that balance (and narrowing the range of optimal structures) as environments become more unpredictable are at the heart of the perspective. The complexity theory view is unique in its focus on processes – i.e. morphing in which the BUs coevolve with changing markets by using a simple rules strategy that enables improvisation; rewiring whereby the BUs create new connections (dissolve obsolete ones) among each other to create synergistic value; and patching in which corporate executives combine, split, add or eliminate, and reassign product-market domains to shape firm scope and BU architecture in coevolution with the environment. While these three processes differ, their common roots in complex adaptive systems are evident – i.e. they emphasize the importance of a moderate degree of structure and the pursuit of coevolutionary adaptation with the environment through the decentralized actions of BU-agents who collaborate and compete with one another in pursuit of self-interest.

We propose several directions for future research. Much of the prior work uses case studies and simulations. While these methods provide a useful toolkit for exploring emergent, nonlinear dynamics that are the mainstay of complexity theory, incorporating other methods may generate novel insights. Recently, some scholars have begun to explore questions related to complexity theory and strategy using large-scale quantitative analysis (see for example, Lenox et al., 2010). Another promising direction lies at the intersection of complexity and networks and questions related to corporate strategy and management. Amaral and Uzzi

(2007: p. 1034) argue for example, that there are 'many management scenarios that exhibit network structures and emergent behavior'. These and other scholars extolled the virtues of network analysis as a way to quantify the relationships and interactions that may arise within a firm and that may shape corporate strategy making. A third research direction has less to do with methodology and more to do with theoretical abstraction. Complexity theory, especially as it has been used in simulation models, has developed in an abstract fashion, and focused primarily on the amount of structure in organizations, centralization, and connectedness. There are opportunities to link the theory more explicitly with the real-world characteristics of organizations. As an example, our understanding of optimal organizational design from a complexity perspective might profit from a more concrete conceptualization of actual structural elements. A final research direction centers on temporal dynamics. Extant studies provide little guidance on appropriate pace of change. While the need for corporate adaptation is clear, we have limited knowledge about the optimal speed of doing so. Overall, there exist several opportunities for new research directions that extend complexity theory with new methods and more explicit linkage of the theory to empirical reality.

We conclude by noting Pagels' (1988: 12) argument that 'Science has explored the microcosms and the macrocosms; we have a good sense of the lay of the land. The great unexplored frontier is complexity'. This quotation reflects our view of future research. Indeed, complexity theory adds a rich understanding of corporate strategy to the organization theory and strategy literatures even as it moves those literatures away from the general linear model (Meyer et al., 2005) and toward a more complex and emergent one. Overall, the holistic and systemic focus of complexity theory is an essential lens to better understand 'the causes of things' in major, diversified corporations.

NOTES

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2 Different ways of conceptualizing complexity exist (see for an overview Lloyd, 2001). For example, an alternative stream of research measures complexity capturing characteristics of the system (Simon, 1976). We regard the measuring of the behavior to be more suitable as the structure itself might be very simple but nevertheless give raise to complex behavior as evident in the example of the logistic map equation (Verhulst, 1838; Ausloos and Dirickx, 2006). Thus, even a deterministic and rather simple equation structure can result in some sort of complex behavior and have dynamical trajectories (May, 1976; Cohen and Stewart, 1994).

3 Almost simultaneously, Crutchfield and Young (1990) coined the expression 'onset of chaos' to describe the same type of phenomenon.

4 A product-market domain consists of the goods and services the organization provides and the market or populations it serves.

REFERENCES

Agarwal, R. and Helfat, C.E. (2009). Strategic renewal of organizations. *Organization Science,* 20(2): 281–293.

Amaral, L.A.N. and Uzzi, B. (2007). Complex systems: A new paradigm for the integrative study of management, physical, and technological systems. *Management Science,* 53(7): 1033–1035.

Anderson, P.W., Arrow, K.J., and Pines, D. (1998). *The Economy as an Evolving Complex System: SFI Studies in the Sciences of Complexity.* Boston, MA: Addison Wesley Longman.

Anderson, P. (1999). Complexity theory and organization science. *Organization Science,* 10(3): 216–232.

Arthur, B. (1989). Competing technologies, increasing returns and lock-in by historical events. *Economic Journal,* 99: 116–131.

Ausloos, M. and Dirickx, M. (2006). *The Logistic Map and the Route to Chaos.* Berlin; New York: Springer.

Axelrod, R.M. and Cohen, M.D. (1999). *Harnessing Complexity: Organizational Implications of a Scientific Frontier.* New York: Free Press. Basic Books.

Bailey, E.E. and Friedlander, A.F. (1982). Market structure and multiproduct industries. *Journal of Economic Literature,* 20(3): 1024–1048.

Bar-Yam, Y. (1997). *Dynamics of Complex Systems.* Cambridge, MA: Perseus.

Berg, N.A. (1973). Corporate role in diversified companies. *Business Policy: Teaching and Research*: 298–347.

Berle, A. and Means, G. (1932). *The Modem Corporation and Private Property.* New York: 355–356.

Berliner, P.F. (1994). *Thinking in Jazz: The Infinite Art of Improvisation.* University of Chicago Press.

Bingham, C.B., Eisenhardt, K.M. and Nathan, R.F. (2007). What makes a process a capability? Heuristics, strategy and the effective capture of opportunities, *Strategic Entrepreneurship Journal*.

Bingham, C.B. and Eisenhardt, K.M. (forthcoming). Rational heuristics: What firms Explicitly learn from their process experiences, *Strategic Management Journal*.

Bonchev, D. and Rouvray, D.H. (2005). *Complexity in Chemistry, Blology, and Ecology.* Springer.

Boulding, K.E. (1964). A pure theory of conflict applied to organizations. *Power and Conflict in Organizations,* London: Tavistock Publications Limited.

Bowman, E.H. and Helfat, C.E. (2001). Does corporate strategy matter? *Strategic Management Journal,* 22(1): 1.

Bradach, J.L. (1997). Using the plural form in the management of restaurant chains. *Administrative Science Quarterly,* 276–303.

Brown, S.L. and Eisenhardt, K.M. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly.* 1–34.

Brown, S.L. and Eisenhardt, K.M. (1998). *Competing on the Edge: Strategy as Structured Chaos.* Boston, MA: Harvard Business School Press.

Burgelman, R.A. (1994). Fading memories: A process theory of strategic business exit in dynamic environments. *Administrative Science Quarterly,* 39(1): 24–56. doi:10.2307/2393493.

Burgelman, R.A. (2002). Strategy as vector and the inertia of coevolutionary lock-in. *Administrative Science Quarterly,* 47(2): 325–357.

Burgelman, R.A. and Grove, A.S. (2007). Let chaos reign, then rein in chaos – repeatedly: managing strategic dynamics for corporate longevity. *Strategic Management Journal,* 28(10): 965–979.

Burns, T. and Stalker, G.M. (1961). *The Management of Innovation.* London, UK: Tavistock.

Chandler, A.D. (1962). Strategy and structure: Chapters in the history of American enterprise. Cambridge: Massachusetts Institute of Technology.

Chandler, A.D. (1991). The functions of the HQ Unit in The Multibusiness Firm. *Strategic Management Journal,* 12 (Winter 91): 31–50.

Chiles, T.H., Meyer, A.D. and Hench, T.J. (2004). Organizational emergence: The origin and transformation of Branson, Missouri's musical theaters. *Organization Science,* 15(5): 499–519.

Ciborra, C.U. (1996). The platform organization: recombining, strategies, structures, and surprises. *Organization Science,* 7(2): 103–117.

Cohen, J. and Stewart, I. (1994). *The Collapse of Chaos – Discovering Simplicity in a Complex World.* Viking Press.

Collis, D. and Montgomery, C. (2004). *Corporate Strategy* 2nd edn. Boston, Mass.: McGraw-Hill/Irwin.

Davis, J.P., Eisenhardt, K.M., and Bingham, C.B. (2009). Optimal structure, market dynamism, and the strategy of simple rules. *Administrative Science Quarterly,* 54(3): 413–452.

Descartes, R. (2006). *A Discourse on the Method.* Oxford University Press, USA, February 16.

Eisenhardt, K.M. and Brown, S.L. (1999). Patching: restitching business portfolios in dynamic markets. *Harvard Business Review,* 77(3): 72–82.

Eisenhardt, K.M. and Galunic, C.D. (2000). Co-evolving: At last a way to make synergies work. *Harvard Business Review,* 78(1): 91–101.

Eisenhardt, K.M. and Martin, J.A. (2000). Dynamic capabilities – What are they? *Strategic Management Journal,* 21: 1105.

Eisenhardt, K.M. and Sull, D.N. (2001). Strategy as simple rules. *Harvard Business Review,* 79(1): 107–116.

Ellis, G.F.R. (2005). Physics, complexity and causality. *Nature,* 435, no. 7043 (June 9): 743. doi:10.1038/435743a.

Ethiraj, S.K. and Levinthal, D. (2004). Modularity and innovation in complex systems. *Management Science,* 50(2): 159–173.

Freeland, R.F. (1996). The myth of the M-Form? Governance, consent, and organizational change. *American Journal of Sociology,* 483–526.

Galbraith, J.R. (1973). *Designing Complex Organizations.* Addison Wesley, October.

Galbraith, J.R. (1974). Organization design: an information processing view. *Interfaces,* 4(3) (May): 28–36.

Galunic, D.C. and Eisenhardt, K.M. (1996). The evolution of intracorporate domains: Divisional charter losses in high-technology, multidivisional corporations. *Organization Science,* 7(3): 255–282.

Galunic, D.C. and Eisenhardt, K.M. (2001). Architectural innovation and modular corporate forms. *Academy of Management Journal,* 44: 1229–1249.

Gell-Mann, M. (1994a). *The Quark and the Jaguar: Adventures in the Simple and the Complex.* New York: W.H. Freeman.

Gell-Mann, M. (1994b). Complex adaptive systems. *Complexity: Metaphors, Models, and Reality,* 19: 17–45.

Gell-Mann, M. (1995). What is complexity? *Complexity,* 1(1): 16–19.

Gell-Mann, M. and Tsallis, C. (2004). *Nonextensive Entropy: Interdisciplinary Applications.* Oxford University Press, USA, April 15.

Gilbert, C.G. (2005). Unbundling the structure of inertia: Resource versus routine rigidity. *Academy of Management Journal,* 48: 741–763.

Gilbert, C.G. (2006). Change in the presence of residual fit: Can competing frames coexist? *Organization Science,* 17(1): 150–167.

Goold, M., Campbell, A., and Alexander, M. (1994). *Corporate-level Strategy: Creating Value in the Multibusiness Company.* New York: Wiley.

Gordon, D.M. (1999). *Ants at Work: How an Insect Society is Organized.* Free Press.

Graebner, M.E. (2004). Momentum and serendipity: how acquired leaders create value in the integration of technology. *Strategic Management Journal,* 25: 751–777.

Gupta, A.K. and Govindarajan, V. (2000). Knowledge flows within multinational corporations. *Strategic Management Journal,* 21(4): 473.

Hansen, M.T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly,* 44(4): 82–111.

Hansen, M.T. (2002). Knowledge networks: Explaining effective knowledge sharing in multiunit companies. *Organization Science,* 13(3): 232–248.

Hargadon, A.B. and Sutton, R.I. (1997). Technology brokering and innovation in a product development firm. *Administrative Science Quarterly,* 42(4): 716–749.

Hatch, M.J. and Weick, K.E. (1998). Critics corner: Critical resistance to the jazz metaphor. *Organization Science*, 600–604.

Helfat, C.E. and Eisenhardt, K.M. (2004). Inter-temporal economies of scope, organizational modularity, and the dynamics of diversification. *Strategic Management Journal,* 25(13): 1217–1232.

Hill, C.W.L. and Hoskisson, R.E. (1987). Strategy and structure in the multiproduct firm. *Academy of Management Review,* 12(2): 331–341.

Hill, C.W.L., Hitt, M.A., and Hoskisson, R.E. (1992). Cooperative versus competitive structures in related and unrelated diversified firms. *Organization Science,* 3(4): 501–521.

Hiller, N.J. and Hambrick, D.C. (2005). Conceptualizing executive hubris: The role of (hyper-)core self evaluations in strategic decision making. *Strategic Management Journal,* 26(4): 297–319.

Holland, J.H. (1975). *Adaptation in Natural and Artificial Systems. A*nn Arbor MI: University of Michigan Press.

Holland, J.H. (1996). *Hidden Order: How Adaptation Builds Complexity.* Basic Books, September 2.

Holland, J.H. (1998). *Emergence: From Chaos to Order.* Perseus Books.

Holland, J.H. and Miller, J.H. (1991). Artificial adaptive agents in economic theory. *The American Economic Review*, 365–370.

Karim, S. (2009). Business Unit Reorganization and Innovation in New Product Markets. *Management Science*, Vol. 55, No. 7, July 2009, pp. 1237–1254.

Kauffman, S.A. (1993). *The Origins of Order: Self-organization and Selection in Evolution.* New York.

Kauffman, S.A. (1995). *At Home in the Universe: The Search for Laws of Self-organization and Complexity.* Oxford University Press, USA.

Kauffman, S.A. (2004). Prolegomenon to a general biology. *Debating Design: from Darwin to DNA*, 151.

Kogut, B. and Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organization Science*, 502–518.

Kretschmer, T. and Puranam, P. (2008). Integration through incentives within differentiated organizations. *Organization Science,* 19(10): 860–875.

Langlois, R.N. (2002). Modularity in technology and organization. *Journal of Economic Behavior and Organization,* 49(1): 19–37.

Langton, C. (1990). *Computation at the Edge of Chaos: Phase Transitions and Emergent Computation.* MIT: Cambridge, MA.

Lenox, M.J., Rockart, S.F., and Lewin, A.Y. (2006). Interdependency, competition, and the distribution of firm and industry profits. *Management Science,* 52(5): 757–777.

Lenox, M.J., Rockart, S.F., and Lewin, A.Y. (2010). Does interdependency affect firm and industry profitability? An empirical test. *Strategic Management Journal,* 31(2): 121–139.

Levinthal, D.A. (1997). Adaptation on rugged landscapes. *Management Science,* 43(7): 934–950.

Levinthal, D.A. and Warglien, M. (1999). Landscape design: Designing for local action in complex worlds. *Organization Science*, 342–357.

Lichtenstein, B.B. (2000). Self-organized transitions: A pattern amid the chaos of transformative change. *Academy of Management Executive,* 14(4): 128–141.

Lloyd, S. (2001). Measures of complexity: A non-exhaustive list. *IEEE Control Systems Magazine* August.

Macintosh, R. and Maclean, D. (1999). Conditioned emergence: A dissipative structures approach to transformation. *Strategic Management Journal*, 297–316.

Martin, J. and Eisenhardt, K.M. (2010) Rewiring: cross-business-unit collaborations and performance in multi-business organizations. *Academy of Management Journal*, Vol. 53, No. 2, 265–301.

May, R. (1976). Simple mathematical models with very complicated dynamics. *Nature,* 261(10): 459–467.

McKelvey, B. (1999). Complexity theory in organization science: Seizing the promise or becoming a fad? *Emergence,* 1(1): 5–32.

Meyer, A.D., Gaba, V., and Colwell, K.A. (2005). Organizing far from equilibrium: nonlinear change in organizational fields. *Organization Science,* 16(5): 456–473.

Micklethwait, J. and Wooldridge, A. (2003). *The Company: A Simple History of a Revolutionary Idea*. New York: Random House Publishers.

Milgrom, P. and Roberts, J. (1990). The economics of modern manufacturing: technology, strategy, and organization. *The American Economic Review*, 511–528.

Miller, J.H. and Page, S.E. (2007). *Complex Adaptive Systems: An Introduction to Computational Models of Social Life.* Illustrated edition. Princeton University Press, March 5.

Miner, A.S., Bassoff, P., and Moorman, C. (2001). Organizational improvisation and learning: a field study. *Administrative Science Quarterly,* 46(2): 304–337.

Murmann, J.P. and Frenken, K. (2006). Toward a systematic framework for research on dominant designs, technological innovations, and industrial change. *Research Policy* 35(7): 925–952. doi:10.1016/j.respol.2006.04.011.

O'Reilly III, Charles, A., and Tushman, M.L. (2004). The ambidextrous organization. *Harvard Business Review,* 82(4): 74–81.

Pagels, H. (1988). *The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity*. Simon & Schuster, January 1.

Panzar, J.C. and Willig, R.D. (1981). Economies of scope. *The American Economic Review*, 268–272.

Pitts, R.A. (1977). Strategies and structures for diversification. *The Academy of Management Journal,* 20(2): 197–208.

Porter, M. (1980). *Competitive Strategy*. New York: Free Press.

Prigogine, I. (1984). *Order Out of Chaos*. Shambhala, August 12.

Prigogine, I. and Stengers, I. (1984). *Order out of Chaos.* New York.

Reynolds, C.W. (1987). Flocks, herds and schools: A distributed behavioral model. In: *Proceedings of the 14th Annual Conference on Computer Graphics and Interactive Techniques*, 25–34. New York, NY, USA: ACM.

Rindova, V.P. and Kotha, S. (2001). Continuous morphing: Competing through dynamic capabilities, form and function. *Academy of Management Journal,* 44(6): 1263–1280.

Rivkin, J.W. (2000). Imitation of complex strategies. *Management Science,* 46(6): 824–844.

Roll, R. (1986). The hubris hypothesis of corporate takeovers. *Journal of Business,* 59(2): 197.

Rumelhart, D.E. (1984). Schemata and the cognitive system. *Handbook of Social Cognition,* 1: 161–188.

Schilling, M.A. and Steensma, K.H. (2001). The use of modular organizational forms: An industry analysis. *Academy of Management Journal,* 44(6): 1149–1168.

Simon, H.A. (1962). The architecture of complexity. *Proceedings of the American Philosophical Society,* 106(6): 467–482.

Simon, H.A. (1976). How complex are complex systems? *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association,* 1976: 507–522.

Simon, H.A. (1996). *The Sciences of the Artificial*. MIT Press.

Sloan, A. (1963). *My Years with General Motors*. 1st ed. Garden City, N.Y., Doubleday.

Teece, D.J. (1980). Economies of scope and the scope of the enterprise. *Journal of Economic Behavior & Organization,* 1(3): 223–247. doi:10.1016/0167-2681(80)90002–5.

Teece, D.J. (1982). Towards an economic theory of the multiproduct firm. *Journal of Economic Behavior & Organization,* 3(1): 39–63.

Tripsas, M. (1997). Surviving radical technological change through dynamic capability: evidence from the typesetter industry. *Industrial and Corporate Change,* 6(2): 341–377.

Tsai, W. (2000). Social capital, strategic relatedness and the formation of intraorganizational linkages. *Strategic Management Journal,* 21(9): 925.

Verhulst, P.F. (1838). Notice sur la loi que la population poursuit dans son accroissement. *Correspondance mathématique et physique,* 10: 113–121.

Wageman, R. and Baker, G. (1997). Incentives and cooperation: the joint effects of task and reward interdependence on group performance. *Journal of Organizational Behavior,* 18(2): 139–158.

Williams, C. and Karim, S. (2008). Promoting inertia: How executives movement influences market entry and exit in medical firms. *Working Paper*.

Williams, C. and Mitchell, W. (2004). Focusing firm evolution: The impact of information infrastructure on market entry by US telecommunications companies, 1984–1998. *Management Science,* 50(11): 1561–1575.

Williamson, O. (1975). *Markets and Hierarchies: Analysis and Antitrust Implications*. New York: Free Press.

Wuchty, S., Jones, B.F., and Uzzi, B. (2007). The increasing dominance of teams in production of knowledge. *Science,* 316 (5827): 1036.