Heuristics for strategic ambidexterity: Balancing exploration and exploitation over time in varying environments

by

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Abstract

Drawing on studies of strategic dynamics and organizational change, this thesis proposes four approaches to balancing exploration and exploitation over time: Specialist, Cyclical, Irregular, and Regular. Various approaches to ambidexterity may be more effective under different environment conditions, and performance may vary along with: 1) varying types of rule change environments, 2) varying levels of competitive intensity among firms, 3) reactive versus proactive timing heuristics, and 4) varying levels of product diversification. Several hypotheses are developed and confirmed using qualitative field research and agent-based modeling. Results indicated that strategic leaders should balance their exploration and exploitation with Regular ambidexterity as their environments become dominated by competence enhancing innovation. Conversely, firms should temporally shift their balance of exploration and exploitation when competence-destroying changes dominate. In a balanced environment, Irregular ambidexterity performs best. These finding are especially relevant in highly competitive contexts. Also, proactive switching increases performance more than reactive switching, whereas diversification reduces the performance of sequential heuristics.

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CHAPTER I: INTRODUCTION

Why are some organizations higher performing than others? Strategic management theory has provided many answers to this question, for instance, by examining industry composition, organizational resources, and their configurations. An emerging school of organizational learning, strategy, timing and evolutionary scholars argues that successful firms balance their exploration and exploitation activities to create both *short-term* and *long-term* performance (e.g., Brunner, Staats, Tushman, and Upton, 2008; March, 1991; Simsek, 2009). Organizational ambidexterity, doing both exploration and exploitation together, has emerged as a key dynamic capability of successful firms (Benner and Tushman, 2003; Gupta, Smith, and Shalley, 2006). Different forms of organizational ambidexterity have been described and studied in the literature, including: strategic alliances, acquisitions, licensing, and internal development (Burgelman, 1991; Gibson and Birkinshaw, 2004; Holmqvist, 2004).

Raisch and Birkinshaw (2008: 397) concluded that the current debate about organizational ambidexterity is mostly "dedicated to questions of organizational design and leadership, while largely ignoring strategic elements", and suggest that future research should develop the notion of "strategic ambidexterity", especially its temporal dimensions (Ancona, Goodman, Lawrence, and Tushman, 2001). A central debate in the current literature revolves around whether and when organizations should balance their exploration and exploitation activities simultaneously or sequentially (Gupta et al., 2006). Empirical research provides preliminary support for both approaches (He and Wong, 2004; Venkatraman, Lee, and Iyer, 2007; Simsek, 2009). However, it remains unclear whether sequential and simultaneous ambidexterity are equifinal or whether they are differentially effective under varying environmental conditions or in combination with other strategies (Chen and Katila, 2008;

Gupta et al., 2006; O'Reilly and Tushman, 2008). To date, research has not paid attention to the specific effect of environmental conditions and organization factors on the success or failure of *timing* approaches to strategic ambidexterity.

This study draws upon several qualitative studies of strategic dynamics and organizational change to identify different approaches to strategic ambidexterity (e.g., Brunner, Staats, Tushman, and Upton, 2008; Lovas and Ghoshal, 2000). Burgelman and Grove (2007) suggest a method for achieving an effective balance that involves shifting between exploration and exploitation over time in response to changes to the institutional, technological, cognitive, and economic "rules of the game". They suggest that superior organizational performance requires that the pace of internal adaptation be matched to the pace of external change, arguing that "strategic recognition" is needed to achieve effective pacing.

This study also draws on active research in artificial intelligence (Rejeb, Guessoum, and M'Hallah, 2005; Wilson, 1996) to develop competing approaches. Artificial intelligence researchers have long struggled to develop effective exploration and exploitation balancing algorithms in the context of the development learning approaches for autonomous agents (e.g., robots and computer players). For instance, if a Mars rover had been autonomous and had the capability to learn from interacting with its environment, then the following scenario ensues. The robot can either respond to an anomaly by doing something that worked in the past, at least some percentage of the time, or it can try something new, such as a combination of past successful strategies with similar background conditions (exploration). Such research has the same premise about autonomous agents as we do in management - learning matters. The strategy the agent develops is a key determinant of its success at navigating unknown environments.

Using the absence and presence of simultaneous and sequential ambidexterity gives four general approaches to ambidexterity approaches: Specialist, Cyclical, Irregular, and Regular, which are presented in a 2 × 2 matrix in Figure 1.1. Firms adopting the Specialist approach are either pure explorers or pure exploiters, that is, they focus on only one type of activity. Firms employing the Cyclical approach switch between being pure explorers and pure exploiters in response to rule changes or other triggers. Firms following the Irregular approach adjust their balance of exploration and exploitation up or down incrementally in response to rule changes or other triggers, never completely eliminating either activity (Burgelman and Grove, 2007). Finally, firms adopting the Regular approach maintain a steady balance of exploration and exploitation over time.

The hypotheses focus on two environmental conditions suggested in the literature: the type of rule change environment and the level of competitive intensity. Rule changes may be competence enhancing for some firms and competence-destroying for others (Anderson and Tushman, 1990). The mix of rule changes in the environment may be a key determinant of the effectiveness of ambidexterity approaches. The type of rule change environment refers to the overall inclination of the environment toward competence destroying innovation, balance, or competence enhancing innovation (D'Aveni, 1999).

FIGURE 1.1

A 2 x 2 Matrix of Strategic Ambidexterity

		Simultaneous Ambidexterity	
		No	**Yes**
Sequential Ambidexterity	**No**	**Specialized** (exploration or exploitation)	**Regular Ambidexterity** (exploration and exploration at the same time)
	Yes	**Cyclical Ambidexterity** (exploration and exploitation, but not at the same time)	**Irregular Ambidexterity** (both exploration and exploration, but shifting between more of one than the other over time)

In environments with high levels of competitive intensity, "the *set of products* judged to be substitutes" (Day, Shocker, and Srivastava, 1979: 10; emphasis in original) is likely to be larger. When buyers scan and compare a smaller proportion of purchase alternatives, the intensity of competition for their sales is lower. The more firms customers consider for transaction, the more difficult it becomes for firms to hide product inferiorities, and they must work that much harder to keep ahead of a larger set of competitors (DeSarbo, Grewal, and Wind, 2006; Griprud and Gronhaug, 1985; Porac and Thomas, 1990). Competitive intensity is a potential moderator of the value of temporal approaches to strategic ambidexterity through the mechanism of external selection.

Firms using the Irregular and Cyclical approaches may also perform better when using proactive switching than reactive switching. Conversely, product diversification as a dampener of the effect of rule change is also studied (Chandler, 1966; Rumelt, 1974; Ramanujam and Varadarajan, 2006). The important role of product diversification was derived from a qualitative field study of a successful organization.

The hypotheses are developed using the logic of evolutionary mechanisms such as external selection, internal selection, and strategic intent. External selection determines winners and losers in an industry through the actions of customers, investors, and other powerful stakeholders (Jacobides and Winter, 2005; Hannan and Freeman, 1989). Internal selection determines rise and fall of strategic initiatives within organizations, through the movement of internal stakeholders seeking projects and responsibilities with the best risk/reward payoffs for themselves (Burgelman, 1991). Related to internal selection is strategic intent, which is an emergent statement of vision or mission set by top managers to guide the actions of members—the objective function of the organization (Hamel and Prahalad, 1990; Lovas and Ghoshal, 2000).

This research combines field study and agent-based simulation; a grounded approach to theory building and a means to confirm the internal consistency of my model and examine its derived inferences. I was influenced by March's (1991) modeling of individual organizations, and informed by the detailed conceptual model of strategic dynamics and heuristics developed by Burgelman and Grove (2007) and by Lovas and Ghoshal, 2000. The field research generated a detailed case study of a successful longstanding organization's approach to strategic ambidexterity, grounding the study in an organizational reality, helping to establish validity for the findings from the simulation, and further refining the conceptual model and hypotheses.

This thesis proceeds as follows. Chapter II provides a review of the relevant literature on exploration and exploitation, organizational ambidexterity, rule changes, and environmental moderators. Chapter III presents a conceptual model and the concept of ambidexterity approaches and related heuristics, and develops several hypotheses about their performance. Chapter IV introduces simulation methods and the design of my simulation, and also describes the methods behind my qualitative field study. Chapter V presents the

results of the simulation and the findings of the qualitative study. Chapter VI discusses the contribution of this research to strategic management theory and practice, proposes areas for future research, and concludes.

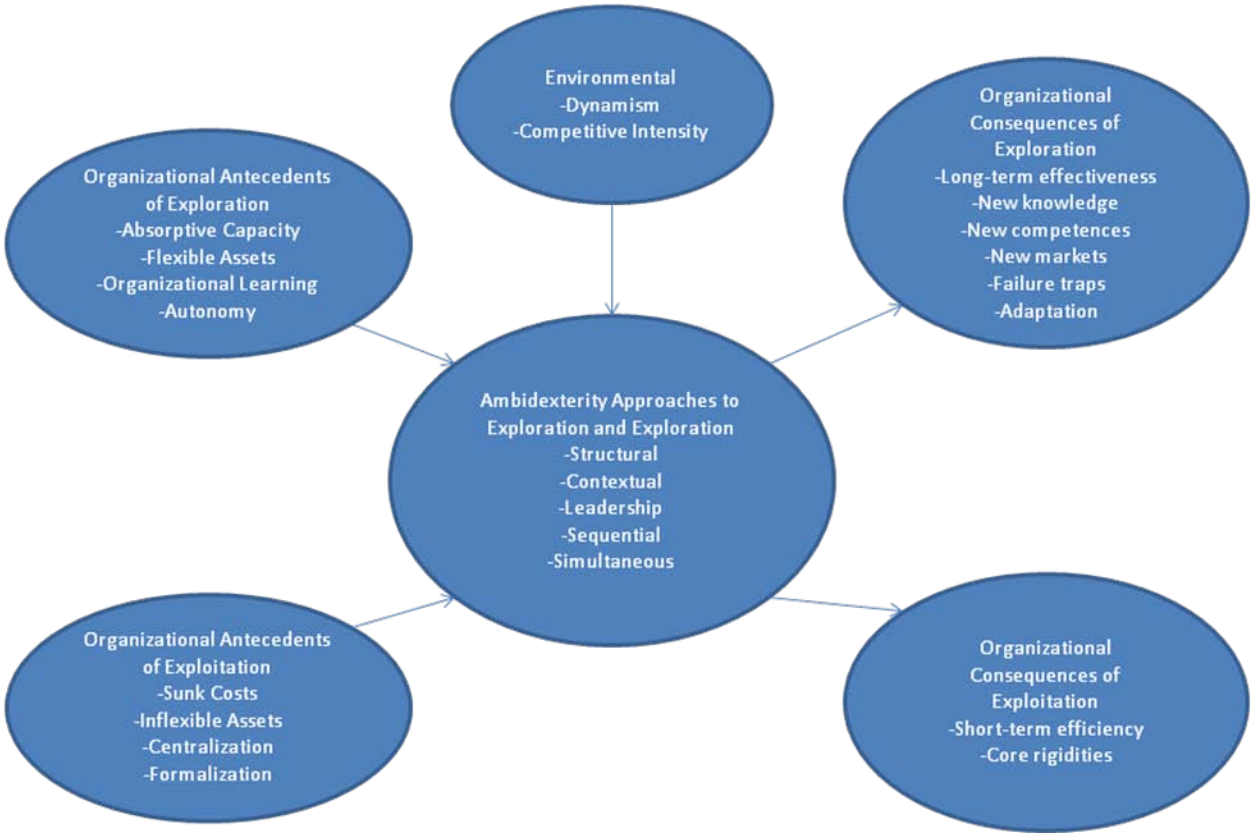
The results confirm that firms should practice sequential approaches to ambidexterity, with proactive heuristics, as the environment becomes increasingly dominated by competence-destroying rule change. However, as environments become increasingly dominated by competence enhancing rule change, firms should avoid shifting between exploration and exploitation sequentially, instead following a Regular approach to ambidexterity. The difference between winners and losers is especially evident when competitive intensity is high. Moreover, the value of sequential approaches (Cyclical and Irregular) decreases as firms diversify their product lines, or use reactive instead of proactive switching heuristics.

CHAPTER II: LITERATURE REVIEW

This chapter reviews the relevant concepts, theories, and empirically supported relationships within the strategic management and organization literatures. Key terms and concepts, including *exploration*, *exploitation*, *ambidexterity*, *rule changes* and *environmental moderators* are defined and empirical findings regarding the interplay of ambidexterity and firm performance and other outcomes are summarized. Finally, I review related simulation research and what has been achieved using these concepts and methods. Figure 2.1 provides a visual overview of the literature reviewed in this chapter.

FIGURE 2.1

Map of the Relevant Literature



As Figure 2.1 suggests, exploration and exploitation have different antecedents, consequences, and ambidexterity may involve several different approaches and are influenced by a variety of environmental forces. Simultaneous ambidexterity increases both exploration and exploitation by reducing the tradeoffs between the two activities, while sequential ambidexterity involves switching emphasis exploration and exploitation over time (Simsek, 2009).

Exploration

According to March (1991:72), exploration includes such things as "search, variation, risk-taking, experimentation, play, flexibility, discovery, and innovation". Holmqvist (2004) reinterpreted exploration as free association, producing intuitive leaps and linkages that lead to innovative new combinations. From knowledge and learning perspectives, exploration can be defined as the pursuit of what might come to be known (Levinthal and March, 1993). As such, it often involves search processes that cross organizational and technological boundaries (Rosenkopf and Nerkar, 2001). For instance, firms that search extra-industry knowledge are more likely to generate valuable innovations (Katila, 2002), whereas intra-industry search yields incremental change.

Exploration allows organizations to create innovative new products, discover previously untapped markets, and develop new resources, capabilities, and competencies (Danneels, 2002; Geroski, Machin, and Van Reenen, 1993). Auh and Menguc (2005) suggest that exploration benefits organizations in the long run by increasing their effectiveness in terms of market share growth, sales growth, and new product introductions. Mitchell and Singh (1993) demonstrated that firms that successfully enter new technological sub-fields are likely to survive but that failed attempts at entry exacerbate incumbent failure.

Whereas the potential benefits of exploration are long-term, its costs are incurred in the short-term. Like basic research, exploration rarely yields benefits early on, yet has some chance of producing value in time (March, 1991). Exploratory projects are *attempts* at new knowledge creation because most recombinations do not produce commercially viable innovations. Levinthal and March (1993) conclude that "most new ideas are bad ones, so most innovations are unrewarding" (p. 106). Stevens and Burley (1997) examined the frequency of successful innovation projects in a large organization, concluding that only one out of every 125 small exploratory projects lead to commercial a success. However, Cohen and Levinthal (1990) argued that firms can improve their exploration success by developing "absorptive capacity", which results from learning from and codifying experience (March, 1991). Similarly, Helfat (1994) suggests that history and idiosyncratic technological trajectories ensure that firms within industries will persistently differ in exploration level and effectiveness[1].

The presence of flexible assets, organizational slack and idle resources are necessary for exploration because they make resources deployable into new contexts (Burgelman, 1991; Lewin, Long, and Carrol, 1999; Voss, Sirdeshmukh, and Voss, 2008). However, other mechanisms, including intra-firm network connectedness and interpersonal learning may also be important catalysts for exploration (Jansen, van den Bosch, and Volbera, 2006; Miller, Zhao, and Calantone, 2006).

In environments with weak intellectual property rights, low strategic complexity and low causal ambiguity, the benefits of exploration may be difficult to appropriate (Rivkin, 2000). The few exploration attempts that do succeed in producing valuable innovations may actually benefit competitors instead of the exploring firm (Levinthal and March, 2003). For

[1] In the language of complex adaptive systems, initial conditions can lead to radically different outcomes (Anderson, 1999).

instance, organizations may not be able to absorb their own innovations because of inertia, or they may lose key human resources to competitors. That innovations can be quickly imitated by competitors has prompted some researchers to regard exploration as a public service with private costs (March, 2006).

The innovations that come out of exploration may be competence enhancing for some firms and competence-destroying for others (Tushman and Anderson, 1986; D'Aveni, 1999). This idea is reflected in Henderson and Clark's (1990) notion of architectural innovations and Christensen's (1998) metaphor of a "disruptive technology". Competence destroying rule changing innovations tend to be exploited by new entrants, while enhancing changes are pursued by incumbents. For instance, Intel's development of Reduced Instruction Set Computing (RISC) technology threatened to lend legitimacy to a technology that could seriously cannibalize its existing sales, prompting the firm to leave it to others to develop (Burgelman, 1991).

Shifting a firm toward exploration by top management dictum may be very difficult because of the informal, decentralized nature of most exploratory projects (Burgelman, 2002). While exploration can come about by top-down decision processes, it usually tends to emerge from bottom and middle levels of organizations that operate with considerable autonomy (e.g., Burgelman, 1991; Lovas and Ghoshal, 2000; McGrath, 2001). For instance, Dougherty and Hardy (1996) found that successful product innovation was "powered by the operational and middle levels of the organizational hierarchies and based largely on the particular networks, connections, and experiences of lower-level managers" (p. 1146). Consequently, exploration may be inhibited by centralized control structures and excessive formalization (Benner and Tushman, 2003; Davis, Eisenthardt, and Bingham, 2007b; Jansen et al., 2006).

Firms that lean too heavily toward exploration may get locked into a vicious cycle of search and failure, or what is known as the "failure trap" (March, 1991; Guptal et al., 2006). This can happen when an organization begins to jump from fad to fad, but never in time to benefit (Abrahamson, 1991). According to Koput (1997), over-searching may negatively influence performance because firms cannot pay attention to and evaluate large numbers of new ideas. Moreover, the new ideas may come at the wrong time or in the wrong place. Meanwhile, exploration diverts resources from other activities, producing certain short-term costs for organizations (e.g., cost of capital, lost opportunities, raw materials, and manpower).

At the system level, Levinthal and March (1993) argued that a climate of exploration acts as magnifier of exploration success. When many industry players simultaneously invest resources in exploration, the higher level of activity magnifies the probability of radical innovation for the whole. As Chen and Katila (2008) suggest, firms may also work collectively to increase or decrease industry change by coordinating their exploration efforts. Uotila, Maula, Keil, and Zahra (2009) found that an industry's research and development (R&D) intensity boosts the value of exploration for firms.

Exploitation

According to March (1991), exploitation includes "such things as refinement, choices, production, efficiency, selection, implementation and execution" (March, 1991: 71). Exploitation can be defined as the use and development of things already known (Levinthal and March, 1993). Specifically, exploitation benefits organizations by allowing them to develop their existing capabilities and take advantage of core competences in the short run (Danneels, 2002). Empirical research has demonstrated that exploitation increases

organizational efficiency in terms of profitability or return on assets (Auh and Menguc, 2005).

Unfortunately, exploitation produces inertial momentum that drives out variability and creates resistance to change (Ahuja and Lampert, 2001; Sørensen and Stuart, 2000). Benner and Tushman (2003) argue that process improvement programs like Total Quality Management (TQM) hamper adopters' ability to innovate radically. Leonard-Barton (1992) argued that exploiting core competencies creates a paradox of core rigidities that inhibit innovation in response to environmental change. Kogut and Zander (1992) attribute exploitation's inertial tendency to the high switching costs involved in changing an organization's core capabilities. Ghemawat and Richart (1993) argue that moving from an exploitation (which they call "static efficiency") orientation to an exploration ("dynamic efficiency") orientation may be inhibited by the presence of sunk costs, opportunity costs, and the need for different types of human resources. Similarly, Gavetti and Levinthal (2000) find that a firm's knowledge legacy constrains its future search trajectories. These insights are reflected by an Intel executive who explained that: "Intel's core microprocessor business had begun to resemble a creosote bush, a desert plant that poisons the ground around it, preventing other plants from growing nearby." (Burgelman, 2002: 326).

Exploitation's tendency toward ossification can prevent organizations from effectively responding to environmental change (Levinthal, 1997). As McNamara and Baden-Fuller (1999: 292) put it: "As the firm hits a performance crisis the natural predisposition of employees is to get out of trouble by focusing on doing what they currently do more efficiently. They rely on the core competencies of the past to deliver success once more." Hill and Rothaermel (2003) observed that while incumbents often fail in the presence of discontinuities, some outliers do survive through mechanisms such as loose-coupling, real-

options decision processes, downstream complementary assets, and value systems that legitimize autonomous developments.

Ambidexterity

> The word 'ambidexterity' is derived from the Latin *ambos*, 'both', and *dexter*, 'right' (as opposed to left). Thus, ambidexterity is 'right on both sides'. - Simsek (2009: 3)

Much has been made of the incompatibility of exploration and exploitation and the consequent tradeoff between them (March, 1991). On one hand, if the two activities are seen as orthogonal dimensions (Gupta et al., 2006), then the basic tradeoff is in allocating resources between them. On the other hand, if the two activities are seen as ends of a single spectrum, then how can organizations be designed for both given that each has a propensity to extinguish the other? As Levinthal and March (1993) put it: "the basic problem confronting an organization is to engage in sufficient exploitation to ensure its current viability and, at the same time, to devote enough energy to exploration to ensure its future viability" (p. 105). March (1991) suggested that the fundamental challenge of management is to find an optimal mix between exploration and exploitation.

Venkatraman et al. (2007) traced the roots of the *ambidexterity* concept back to Penrose's (1959) growth trajectories, Thompson's (1967) paradox of administration, and Cyert and March's (1963) behavioral theory of the firm. Duncan (1976) coined the term to refer to the managerial trade-offs between the conflicting requirements of alignment (exploitation) and adaptation (exploration) activities within and between organizations. He suggested that organizations use "dual structures", such as separate business units or groups within units, to manage the inherent conflict between the two activities. These earlier works have been interpreted as regarding exploration and exploitation as fundamentally

incompatible activities requiring separate organizations. This view was echoed by Christensen (1998) who popularly explained how "disruptive technologies" can undermine the competitive position of established firms, such that incumbents should spin off exploratory businesses into separate units when they involve technologies that are incompatible with those of the current business. This approach has been criticized, for instance, by Dougherty and Hardy (1996) who argue that "new products are inextricably bound up with the rest of an organization, so avoiding the connections is not a real solution" (p. 1122). However, disruptive technologies often start with lower value applications by marginal customers and eventually improve to dominate the current business (Christensen, 1998). As such, they are more likely to be brought forth by new entrants than by incumbents who may not want to legitimize the new technology (Christensen and Bower, 1996).

Another interpretation of organizational ambidexterity refers to the degree of organizational structure, as measured by centralization, formalization or number of rules of an organization (Brown and Einsenhardt, 1997). Too much structure reduces a firm's flexibility, making exploration more difficult, while too little structure prevents exploitation and appropriation of returns to innovation. This stream generally proposes that *semi-loose coupling* is advantageous to firms (Galunic and Eisenhardt, 2001). Notably, Davis et al. (2007b) observe that the tension between too little and too much structure is "*asymmetric* such that leaders should favor more structure" (p. 44), especially in more entrepreneurial firms. Benner and Tushman (2003) extend this notion, suggesting that organizing for ambidexterity involves tight coupling within sub-units that are loosely coupled together; for instance, highly internally coordinated groups that cooperate through political activities and negotiation. Fang, Lee, and Schilling (2010) constructed a simulation to further validate this idea, concluding that organizations should be structured into semi-isolated groups to enable a measured flow of ideas.

O'Reilly and Tushman (2008) question whether organizational ambidexterity is just a matter of structure, framing it as a leadership problem. Smith and Tushman (2005) argue that senior executives may enable their organizations to balance exploration and exploitation by establishing paradoxical cognitive frames and processes. Lubatkin, Simsek, Ling, and Veiga (2006) suggest that top management teams can develop ambidextrous orientations in their firms by encouraging behavioural integration, which they define as "synchronizing the social and task processes associated with collaborative behavior, quality of information exchange, and joint decision making." (p. 651). Others have also proposed intra-firm network connectedness and interpersonal learning as enablers of organizational ambidexterity (Jansen et al., 2006; Miller et al., 2006). Kane and Alavi (2007) point to the role of email, knowledge repositories and other information systems for increase/decreasing knowledge heterogeneity within firms, and argue that their selective use can enable exploration and exploitation.

Recent works have focused on contextual ambidexterity rather than structural ambidexterity (Gibson and Birkinshaw, 2004). Contextual ambidexterity combines exploration and exploitation activities within the same groups and business units, such that they occur together. This effectively juggles the need to compete in current markets and emerging markets simultaneously (Van Looy, Martens, and Debackere, 2005). Gibson and Birkinshaw (2004) argued that the contextual features of discipline, stretch, support, and trust (Ghoshal and Bartlett, 1994) are key enablers of ambidexterity for individuals. This view contrasts with the notion that exploration and exploitation involve trade-offs by suggesting that it is possible for organizations to *align themselves around adaptability*. Qualitative research on Toyota suggests that it embeds exploration into its exploitation routines, such that innovation becomes an integrated part of its organizational DNA (Adler, Goldoftas, and Levine, 1999; Brunner et al., 2008).

Ambidexterity increases a firm's chances of survival, at the expense of short-term profit maximization, by diverting resources to exploration projects that will not yield benefits until many years into the future (March, 1991; Probst and Raisch, 2005). Measures of exploration and exploitation range between keyword counts (Uotial et al., 2009), patent search scope (Katila and Ahuja, 2002), boundary spanning search (Rosenkopf and Nerkar, 2001), external search breadth and depth (Laursen and Salter, 2006), and activity newness (McGrath, 2001). Notably, He and Wong (2004) developed an index to measure exploration and exploration as orthogonal concepts. Their items measured organizational exploration by counting instances of new product generations, product range extensions, new market openings, and new technology field entry. Likewise, exploitation was measured by counting improvements to existing product quality, production flexibility improvements, production cost reductions, and improvements in yield, or reduction of material consumption. They found that organizations that do more of both exploration and exploitation, and have a small gap between the levels of the two activities, exhibited higher sales growth than organizations that do less of both, and have larger gaps between them. However, this snapshot approach does not capture the temporal dynamics of sequential approaches to ambidexterity. Also, Raisch and Birkinshaw (2008) point out that most empirical research has examined the relationship between ambidexterity and *short-term* performance outcomes (e.g., He and Wong, 2005; Lubatkin et al., 2006), whereas exploration is expected to have *long-term* consequences on firm performance.

Researchers have also begun to distinguish between simultaneous and sequential approaches to ambidexterity. Recent reviews have attempted to steer future research toward identifying whether sequential or simultaneous ambidexterity are distinct, and if so, which approach is better (Chen and Katila, 2008; O'Reilly and Tushman, 2008). The simultaneous approach works by maintaining a steady balance of exploration and exploitation over time.

The sequential method incorporates switching between cycles of exploration and exploitation, effectively balancing over time. Siggelkow and Levinthal (2003) propose temporary decentralization, with subsequent reintegration, as a means to higher long-term performance when organizations face a major environmental change.

Venkatraman et al. (2009) found sequential ambidexterity to be more effective in the software industry. Their measure of sequential ambidexterity "reflects [a] temporal sequence of routines that balance exploration (i.e., time *t-1*) and exploitation (i.e., time *t*) in two successive time periods" (p. 8). They used Standard Industrial Classification (SIC) data reflecting the number of product introductions the firms made within an existing industrial domain (related diversification) and across to new domains (unrelated diversification). However, their measures require the interval to be specified *a priori*, rather than allowing the data to describe the punctuations. In other words, they presume strict intervals of equal lengths, whereas, in reality, firms may have intervals of varying length. Specifically, they use one and two year intervals, while qualitative studies suggest intervals may vary greatly within and between firms and industries (e.g., Burgelman and Grove, 2007; Lovas and Ghoshal, 2000). They also do not account for the role of rule changes and other triggers, which may guide strategist's actions regarding when to increase (decrease) exploration (exploitation). For instance, a firm may react to a competitor's adoption of low cost production by differentiating along new product dimensions through innovation.

Organizational Moderators

Many organizational moderators have been demonstrated to increase a firm's ability to achieve ambidexterity; for instance, dual structures and behavioral approaches to management (Duncan, 1978; Gibson and Birkinshaw, 1996). In contrast to these approaches to implementation, the focus of this study is on the organizational timing strategies that guide

organizational decision making about implementation (Burgelman and Grove, 2007; Auh and Menguc, 2005).

Proactive versus Reactive Switching

Firms may shift resources between exploration and exploitation for many different reasons, including executive successions, poor financial performance, external financial shocks, key shareholder bankruptcies, the adoption of new process or product technologies by competitors, and shifts in top management conceptions of the internal and external environment (Lovas and Ghoshal, 2000; McNamara and Baden-Fuller, 1999). Burgelman and Grove (2007) argue that firms should switch between exploration and exploitation proactively in response to rule changes.

> "Rule changes are [changes to the] . . . 'rules of the game:' normative rules based on laws, customs, and administrative principles; technological rules based on available technical solutions; economic rules reflecting existing bargaining power relationships among the industry players (often captured in contracts); and cognitive rules that are widely shared judgments about key success factors" (Burgelman and Grove, 2007: 966).

Strategic leaders may learn to detect and respond to rule changes early, before competitors do, a capability called strategic recognition (Baron, 2006; Burgelman and Grove, 2009; Grove, 1996). Firms with effective strategic recognition are expected to gain competitive advantage because they are better at spotting material changes before others, allowing them to respond proactively. For instance, Intel did not wait until its Dynamic Random Access Memory (DRAM) business completely collapsed before switching to design competencies in Complex Instruction Set Computing (CISC). To date, little is known about the effectiveness of proactive versus reactive switching heuristics.

Environmental Moderators

No single environmental factor has received as much attention as environmental turbulence or dynamism, which refers to the rate of change and the degree of unpredictability of selected elements of the environment (Dess and Beard, 1984). Market dynamism measures changes in demand, and technological dynamism examines the nature of technological change (Jansen, Vera, and Crossan, 2008; Haleblian and Finkelstein, 1993; Kim and Rhee, 2009; Virany, Tushman, and Romanelli, 1992).

Highly dynamic environments are characterized by rapid discontinuous changes in demand, competition, technology, or regulation. Dynamism increases uncertainty, decreases information accuracy, and makes organizational ambidexterity difficult to practice (Simsek, 2009). Consequently, March (1991) suggested that the value of exploration increases with the level of environmental turbulence. The basic logic is that existing competencies obsolesce quickly in dynamic environments, calling for the development of new competencies (Daneels, 2002). Given that exploration increases the variance of organizational activities (McGrath, 2001), it ought to enhance the organization's ability to adapt to a changing environment (Sidhu, Volberda, and Commandeur, 2004). This also suggests that, while exploration is the best individual choice as a collective strategy, it serves to increase environmental dynamism (Levinthal and March, 1993).

Chen and Katila (2008) observe that "firms engage in lengthy periods of exploitation . . . and only shift to an exploration phase when the industry is in search of a new dominant design" (p. 209). They claim that industries experiencing constant environment change, such as robotics (Katila and Ahuja, 2002), information technology (Brown and Eisenhardt, 1997; Jansen et al., 2006), business to business (Daneels, 2002), and medical equipment (Karim and Mitchell, 2000), need to explore continually. Meanwhile, stable businesses like cement,

airlines and movies experience a punctuated equilibrium pattern of change and may need to explore only from time to time, not continually (Miller and Shamsie, 2001; Tushman and Anderson, 1986).

O'Reilly and Tushman (2008) contend that firms employ simultaneous ambidexterity under dynamic conditions, and sequential ambidexterity under stable conditions. Continuously balancing exploration and exploitation may be more important in a highly dynamic environment so that the organization can change along with it, while the requirement for exploration is reduced in slow moving environments as the need for change is reduced (Caldart and Ricart, 2008; McGrath, 2001), and "individuals may perceive transformational leadership with its focus on challenging assumptions as distracting and superfluous" (Jansen et al., 2008: 10). Meanwhile, Venkatraman et al. (2007) find evidence that software firms, a industry context normally considered to be highly dynamic (e.g., Nadkarny and Narayanan, 2007), do better by practicing sequential ambidexterity. Thus, the current literature is contradictory about the environmental conditions in which simultaneous and sequential approaches to ambidexterity are most effective.

In addition to dynamism, competitive intensity has also been proposed as a key environmental moderator of ambidexterity and firm performance. Competitive intensity in a product-market is reflected in "the *set of products* judged to be substitutes" (Day, Shocker, and Srivastava, 1979: 10; emphasis in original). The proportion of purchase alternatives that buyers consider and compare to select the best supplier to buy from may be smaller in some industries than others. For example, customers' firms may consider only a proportion of their suppliers as relevant (DeSarbo, Grewal, and Wind, 2006; Griprud and Gronhaug, 1985; Porac and Thomas, 1990). Where customers evaluate many firms in making their buying decisions, competitive intensity is higher. When more information enters into the decision, customers have more opportunity to compare products when deciding who to buy from.

Jansen et al. (2005; 2006) empirically examined the effect of competitiveness on organizational ambidexterity using cross-sectional survey data, finding that it increased the need to pursue exploration and exploitation simultaneously. Auh and Menguc (2005) found that, as competitive intensity increases, defenders (incumbents) benefit more from exploration than exploitation. Conversely, as competitive intensity decreases, prospectors (new entrants) benefit more from exploitation than exploration.

Prior Simulation Studies

This section reviews several simulations that have been used to develop theory in related areas. The purpose is to give an overview of how simulations have contributed to theory development, and to demonstrate how different simulation styles can be used to tackle different research questions. This may be useful for those who are not familiar with the legacy of simulation research in the field. It gives a survey of different flavors of simulation and examines their strengths, weaknesses, applications, and limitations.

March (1991) developed an agent-based simulation that helped elaborate theory linking a balance of exploration and exploitation to firm performance. He designed a model of an organization balancing exploration and exploitation through the interaction of multiple agents (organizational members) and learning rules, and derived their organizational outcomes firms, much like a special case of the more general problem of learning a moving target (Wilson, 1996). His simulation modeled a single organization with an organizational code representing the explicit or routinized knowledge of the firm, and several employees with heterogeneous knowledge. The environment was modeled as a string of random bits corresponding to varying conditions. As the simulation progressed, the organization code was updated to reflect the accurate knowledge of employees, and the employees' knowledge was updated to reflect the organization code. Thus, after several iterations, the employees'

knowledge converged with that of the code. Firm performance was calculated as the degree of similarity between the organization code and the string representing the environment at the end of the simulation. He conceptualized level of exploration as the gap between the code and the knowledge of employees, suggesting that employee turnover (voluntary or otherwise) and the presence of slow learners (non-conformers) increases firm performance in turbulent environments. New employees and slow learners provide the variability of ideas needed for firms to adapt to changing environmental conditions.

Miller et al. (2006) modified March's (1991) simulation, adding tacit knowledge, interpersonal learning, and geographic proximity to the model. They demonstrated that the high levels of interpersonal learning may effectively substitute for an organization code, especially when high levels of tacit knowledge are involved, which cannot easily be converted into the explicit codified knowledge of firms (Nonaka, 1994). However, minimal geographic proximity was needed to keep the flow of communication and to avoid regional cliques. Rodan (2005) modified the model by adding managerial promotion strategies. He concluded that firms should lean toward promotion based on shorter individual performance histories rather than seniority.

Sastry (1997) used a system dynamics simulation to examine the effect of reorganization on firm performance. Her model pitted organizational inertia against pressure for change resulting from poor firm performance, and it demonstrated that suspension of change during a trial period increased firm performance. She concluded from her study that firms should employ internal pacing to create periods of stability in the face of high levels of environmental turbulence, providing evidence for the usefulness of dynamic temporal heuristics (e.g., Irregular and Cyclical).

Davis et al. (2007) constructed an agent-based simulation to examine the tension between flexibility and efficiency, which they model as a firm's level of structure. They

conceived of structure as the number of rules firms used when deciding which opportunities to pursue and which to ignore. They found that the relationship between too much structure and too little structure is asymmetric, such that firms (especially entrepreneurial start-ups) should favor more structure over less structure. Much like March's organizational code, their selection rules determined firm performance by matching randomly generated opportunities (the environment). They concluded that just a few rules (3-7) may be the best combination.

Siggelkow and Levinthal (2003) used an NK fitness landscape (Holland, 1975) to examine how decentralization can help firms facing environmental change. In the face of a major discontinuity, they compared firms that effectively split into two autonomous strategic sub-units to those that remained intact. They concluded that firms should temporarily decentralize their strategic decision making processes, then reunite them shortly after discontinuities. Splitting a firm into two autonomous search agents in the face of discontinuity then recombining them is better than simply plowing ahead with a single local optimum because two independent searchers find a better alternative in the long run, whereas the single searcher finds a better solution in the short run.

All of these simulations share two important commonalities. Although three different approaches to simulation we employed, all of them modeled *single firms* with *random external environments*. In each case, the performance of the firm was determined by matching its knowledge or competences to the demands of the environment or landscape. While appropriate for the problems they were intended to examine, these design decisions limit the potential for examining competitive situations where the environment is largely a reflection of the firms contained in it (see Lee and Ryu, 2002 for an example). For instance, they cannot model a situation where the successful innovation by one firm constitutes a discontinuity for others, which is of key importance when examining the strategic dynamics

of firms facing rule change. This is an important point, which is addressed by the simulation design of this study, and which is fully-articulated in the Methodology chapter.

CHAPTER III: MODEL AND HYPOTHESES

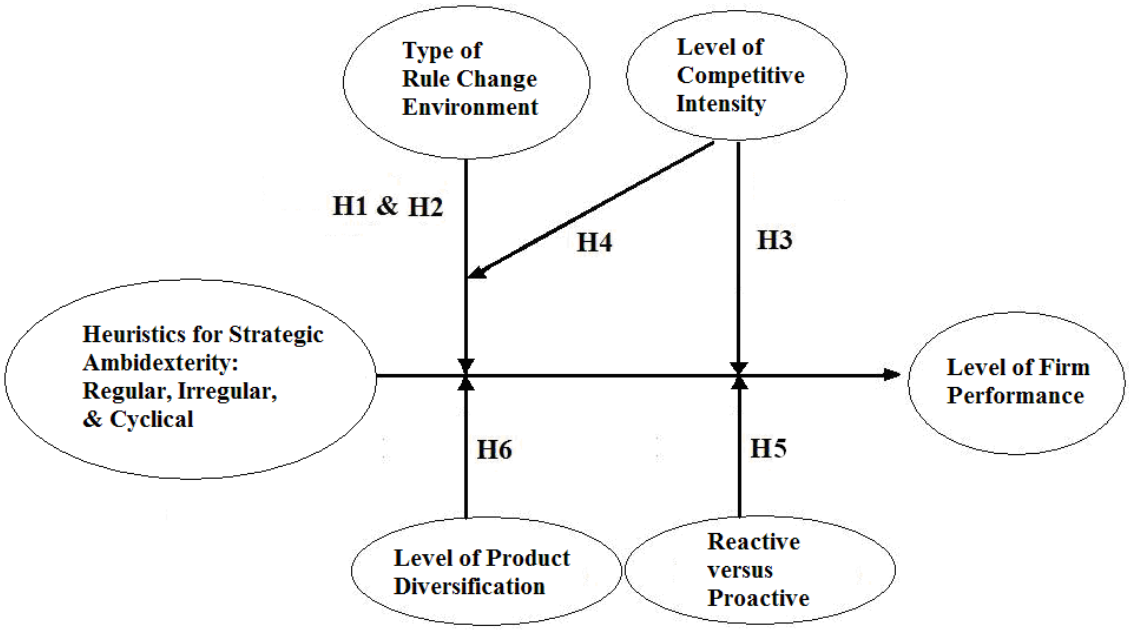
Theoretical Model

This chapter develops a model of strategic ambidexterity focusing on the strategic timing elements involved in balancing exploration and exploitation in configurations with environment and organizational characteristics. It then elaborates several hypotheses, drawing on previous literature on exploration and exploitation (March, 1991), evolutionary mechanisms (Burgelman, 1991) and strategic intent (Lovas and Ghoshal, 2000). The conceptual model shown in Figure 3.1.

The dependent variable is firm performance. The independent variables are the heuristics for strategic ambidexterity, including the Regular, Irregular, and Cyclical approaches developed in the following sections. There are two environmental moderators: type of rule change environment and competitive intensity. Type of rule change environment refers to whether the environment is dominated by competence enhancing innovations, competence-destroying innovations, or balanced between both forces. Level of competitive intensity refers to the number of competitors the customers consider before making purchase decisions. Finally, proactive or reactive switching and level of product diversification moderate the effect of the heuristics for strategic ambidexterity on level of firm performance.

FIGURE 3.1

Conceptual Model



Heuristics for Strategic Ambidexterity

Each of the four approaches to balancing exploration and exploitation (Specialist, Regular, Irregular, and Cyclical) involve heuristics, which are specific flavors of approaches to ambidexterity. A heuristic is a simple rule or "rule of thumb" that managers may develop over time and serve as cognitive simplifications that allow managers to make sense of their world (Cyert and March, 1963; Rivkin, 2000). Heuristics are used extensively in artificial intelligence literature to refer to strategies taken by a computer agent when the best possible sequence of moves is intractable to calculate (Wilson, 1996). For instance, it takes existing computers years to calculate ideal moves for some board positions in chess, therefore the programmer is forced to build in shortcuts for playing well, but imperfectly.

> "If complexity renders global optimization intractable . . . one must presume that thoughtful managers realize the nature of the challenge they face and opt not to

> attempt global optimization. Rather, they likely employ judgment and heuristics to find good, albeit not necessarily optimal, sets of decisions."
> - Rivkin (2000: 826)

Rule-changing strategic dynamics are nonlinear and unpredictable (intractable). For instance, moving to a new method of manufacturing may be considered rule-changing, because competitive parity may not be regained without substantive investments (Burgelman and Grove, 2007). Rule changes shift the basis of competition to new dimensions (e.g., from design to manufacturing, or from manufacturing to marketing), undermining some competences and favoring others. Game theoretic models, exhaustive search, and other analytical techniques may be appropriate for tractable games, but heuristics are required for intractable games. In short, managers must rely on heuristic rules to deal with rule-changing strategic dynamics (Burgelman and Grove, 2007).

To fully define an ambidexterity heuristic, we need to know its possible states and how and when to move between states. This is not a problem for Specialists, as both "pure exploiters" and "pure explorers" (see Figure 1.1) tend toward zero exploration and zero exploitation, respectively, under all conditions. However, a firm adopting the Cyclical heuristic must know when to switch between being a "pure explorer" and a "pure exploiter". On the other hand, a firm using the Regular heuristic must know the location of its central tendency (the firm's optimal balance of exploration and exploitation). Critically, a firm practicing Irregular ambidexterity needs to know its minimum and maximum bounds, when to move between them, in which direction (upward or downward), and whether to move between them all in one shot, or to increment upward or decrement downward, slower, at the same rate, or faster.

These ideas will be illustrated with examples shortly, but it may be helpful to think of each heuristic as a simple algorithm. Let us imagine that the Specialist and Regular heuristics

are single parameter heuristics (exploration = X, exploitation = 1 - X). For the Specialist, X must always be 0 (pure exploiter) or 1 (pure explorer). For the Regular heuristic, X may be any level between 0 and 1, and this level is maintained over time through savvy resource allocation. The Cyclical heuristic oscillates between those two extremes, requiring a second parameter in addition to X, triggering it to switch X between 0 and 1. Let us call this parameter a trigger and refer to it as T. The Irregular heuristic requires X and T, but also needs additional parameters to determine its Minimum and Maximum levels of X. Furthermore, given that X may change in response to T, I also need to know how much to Increment or Decrement and in which Direction. Hence, the Irregular heuristic involves seven parameters.

There is an inherent trade-off between exploration and exploitation in the context of organizations. Too little exploitation will lower survival chances, as imitators quickly catch up and surpass innovative firms that lack the ability to exploit new discoveries (Levinthal and March, 1993; Lewin, et al., 1999). Too much exploitation also reduces long run performance by producing inertia that makes organizations less able to respond to innovations (Benner and Tushman, 2003). Exploration of new alternatives must reduce the speed with which existing competences may improve, while improvements in existing competences make experimentation with other alternatives less attractive (March, 1991). Thus, this study assumes that exploration and exploitation are a single dimension (i.e., Exploration = 1 – Exploitation), making for a continuum[2].

This study examines how firms achieve balance over time, i.e., their "rhythm" of exploration and exploitation (Brown and Eisenhardt, 1997). The heuristics do not differentiate between means of implementing balance, i.e., structure (Davis et al., 2007;

[2]An alternative conceptualization might be to view exploration and exploitation as orthogonal activities (separate dimensions) occurring at the same time within individuals (Gibson and Birkinshaw, 2004; Gupta et al., 2006), which could be examined in future research.

Duncan, 1976), context (Gibson and Birkinshaw, 2004) or network alliances (Holmqvist, 2004). These are considered different forms of implementations, that is, they may be equifinal in their application to sequential and simultaneous approaches to strategic ambidexterity, which is concerned with the timing of managerial activities.

Specialized Explorers and Exploiters

Although no formal hypotheses are made about the performance of specialized explorers and exploiters, these approaches are introduced for the sake of completeness. Some firms may observe one of two specialist heuristics; the "pure explorer" and the "pure exploiter" (see Figure 1.1). Pure exploiters do little to no exploration, while pure explorers do little to no exploitation. Most research suggests that specializing in either pure exploitation or pure exploration is hazardous to long-term organizational survival (e.g., March, 1991), unless collaborations between firms are allowed. For instance, strategic alliance between opposing specialists may make for a stable whole, but then the two firms would be considered here as one. It may be practically impossible to avoid exploration or exploitation entirely, but they may be treated as ideal types.

Specialist strategies may be organization lifecycle dependent. Smaller, younger firms have fewer resources to devote to non-core activities (Danneels, 2002; Kogut and Zander, 1992; Welsh and White, 1981). Conversely, most start-ups fail, and those that do succeed must eventually engage in some exploitation in order to survive (O'Reilly and Tushman, 2008). Ebben and Johnson (2005) provide empirical evidence that smaller firms with limited resources and expertise perform better by specializing in efficiency or flexibility rather than by mixing the two activities. Smaller organizations cannot internalize the evolutionary (variation–selection–retention) process inherent in markets to create an internal selection

environment within the firm, and thus, face life-or-death on just a few bets (Burgelman, 1991).

Conversely, the environmental context may provide structures that allow firms to specialize (Gupta et al., 2006). For instance, exploratory firms may enter into exploitation alliances with other partners, or exploitative firms may engage exploratory partners (Holmqvist, 2004). Firms may increase their odds of participating in innovation by shaping their alliance networks (Vanhaverbeke, Gilsing, Beerkens, and Duysters, 2009). These mechanisms provide evidence of dual structures (Duncan, 1976), whereby the environmental context spreads the burden of exploration and exploitation across a network of firms. Alliances are inter-organizational forms of structure and therefore also applicable implementations of sequential (Irregular and Cyclical) and simultaneous (Regular) approaches to ambidexterity.

Regular Ambidexterity

Firms using the Regular[3] heuristics explore and exploit at the same time through structural or contextual ambidexterity (Gibson and Birkinshaw, 2004). Thus, over time, their balance of exploration and exploitation remains roughly stable. For instance, a firm using Regular ambidexterity might invest 20-25% of its developmental resources in exploration, consistently for many years. Firms using Regular ambidexterity may survive by entraining themselves to internal and external rhythms of change (Ancona et al., 2001). For instance, an industry-leading firm may set the pace for the industry according to its own highly stable rhythm innovation and change (Anconna and Chong, 1996).

Like perfect specialization, achieving perfect regularity may also be impossible. For instance, firms using the Regular heuristic may actually be changing continuously, but in

[3] Note that regular firms with very high or very low levels of exploration (i.e. less than 5% or more than 95%) are effectively specialized firms.

enough opposing directions as to give the impression of stability over time. For instance, Brown and Eisenhardt (1997) argue that high-velocity environments require firms to change continuously. One might imagine a sine wave with high frequency but low amplitude. There is constant shifting going on inside but the level of exploration remains stable over time, with almost no highs and low.

An alternative explanation for Regular ambidexterity is that highly disciplined organizations may deliberately perturb or disrupt their own operations at many levels simultaneously in order to stimulate regular exploration (Adler et al., 1999; Brunner et al., 2008). Continual perturbation[4] prevents the onset of stagnation from exploitation activities, such as process improvement and quality management programs, which are known to produce creative atrophy (O'Reilly and Tushman, 1996). In short, the Regular heuristic is the case of continual small changes that balance out.

Cyclical Ambidexterity

Firms following only Cyclical ambidexterity do not explore and exploit simultaneously, but, rather, oscillate between periods of pure exploration and exploitation sequentially over time. There is preliminary support for the contention that sequential ambidexterity is preferable in some contexts. For instance, Venkatraman et al. (2007) found that software firms that explored and exploited sequentially had higher sales growth than those that did so simultaneously.

Accounts from qualitative studies point to reasons why a firm might become Cyclical in its approach to strategic ambidexterity. Lovas and Ghoshal (2000) described the case of Oticon, a European hearing aid company, which invested heavily in exploration after having

[4] Examples of deliberate perturbations at Toyota include: purposefully shrinking inventory buffers, experimentation by assembly line workers, and building the Lexus line in the same factory as non-luxury cars (Brunner et al., 2008).

exploited its current products into obsolescence. Oticon lost considerable market share before a senior executive decided to visit customer locations to see why the company was falling behind the competition. Oticon was late to recognize two rule changes by other companies: 1) hearing aids to be placed in the ear, and 2) hearing aids with automatic volume and tone control. The company then invested heavily in exploration to replace their outdated products, and survived. Similarly, Dyck, Starke, Mischke, and Mauws (2005) describe the case of single product automotive company that essentially ceased production for several weeks as it retooled and redesigned its product (exploration) to meet regulatory requirements, before restarting production (exploitation) several months later, and at significant expense.

Firms employing Cyclical heuristics may either have poor strategic recognition (Burgelman and Grove, 2007) or deliberately ignore some rule changes while acting on others. Oticon could not rely on autonomous strategic processes; it needed top management to sponsor exploration through a strategic innovation initiative. Conversely, Cyclical firms may attempt to be market timers, waiting for optimal environmental conditions (Levinthal and March, 1993).

Whereas Oticon was successful, researchers warn that inducing innovation from the top is often very difficult due to inertial forces (Burgelman and Grove, 2007) and potentially maladaptive because most new ideas never lead to commercial success (Levinthal and March, 1993; March, 1991; Stevens and Burley, 1997). Also, Boyd and Bresser (2008) demonstrate that firms that are slow to react to the strategic actions of competitors tend to perform poorly and fail to gain first mover advantages.

Irregular Ambidexterity

The Irregular heuristic best matches Burgelman and Grove's (2007) discussion of Intel's heuristic for managing non-linear strategic dynamics. They contend that rule changes

(e.g., environmental shocks) are rarely foreseen because they creep out of the blind spots in managers' mental models. However, strategic leaders may learn to recognize rule changes before others do, a capability called "strategic recognition" (Burgelman and Grove, 2007: 968), which they liken to form of directed paranoia (Grove, 1996) that distinguishes the leadership of successful firms like Intel from others.

In their longitudinal analysis of Intel Corporation, Burgelman and Grove (2007) developed a heuristic for balancing exploration and exploitation over time. According to them, "*strategic* leadership—how top management designs the strategy-making process" is fundamental for balancing exploration and exploitation to maximize short-term fitness as well as long-term evolvability (Burgelman and Grove, 2007: 967; emphasis in original). In other words, firms survive by dynamically shifting emphasis between exploration and exploitation in response to non-linear trends, but never completely extinguish exploration nor exploitation.

Using ideas from game theoretic and complex adaptive systems approaches, Burgelman and Grove (2007) elaborate a model for attaining corporate longevity in the face of non-linear industry dynamics. They argue that corporate success in the long run depends upon strategic leaders' ability to recognize and respond to non-linear dynamics caused by industry players' introduction of strategic innovations (e.g., greening, globalization, and digitization strategies), thereby changing the rules of the game in the industry. They build on the Bower-Burgelman multilevel process model of strategy-making using an internal ecology approach to complex organizations (Bower and Gilbert, 2005; Burgelman, 1991, 1996, 2002; Noda and Bower, 1996). Drawing upon their interviews with hundreds of managers, observations of planning meetings, study of company documents from 1988 to 2005, and extensive executive experience of company's strategic dynamics for more than 35 years, they

analyze Intel's evolution over time.[5] Intel is an important case because of its dominant role in the development of the Information Age, and due to the insight and experience of its executives.[6]

Figure 3.1 presents the proportion of developmental resources devoted to exploration and exploitation at Intel over the years based on data provided in Burgelman and Grove (2007).[7] Using retrospective accounts from executives and an analysis of company documents, they were able to reconstruct the company's resource split between autonomous strategic processes (exploration) and induced strategic process (exploitation). From 1976 to 2005, Intel changed its balance of exploration versus exploitation several times, shifting resources across five different businesses: dynamic random access memory (DRAM) products, CISC (Complex Instruction Set Computing) microprocessors, RISC (Reduced Instruction Set Computing) microprocessors, network-communications microprocessors, and platform microprocessors.

As depicted in Figure 3.1, in 1976, Intel had 75% of its developmental resources dedicated to DRAM products (for exploitation) and 25% to CISC microprocessors (for exploration). During late 1970s and early 1980s, Japanese manufacturers fundamentally changed the rules of DRAM business by investing in process technologies that reduced their production cost. Thus, manufacturing rather than circuit design competence became the basis of competition. Anticipating the commoditization and decline of its DRAM products, in 1984, Intel shifted 10%[8] of its developmental resources from exploitation of DRAM business

[5] Andy Grove joined Intel in 1968 and was its President (1979-1987), CEO (1987-1997), and Chairman (1997-2004).

[6] For example, Moore's law, after Gordon E. Moore, Intel's co-founder, which describes a long-term trend in the history of computer hardware—roughly doubling the number of transistors on a chip every 18-24 months for half the cost.

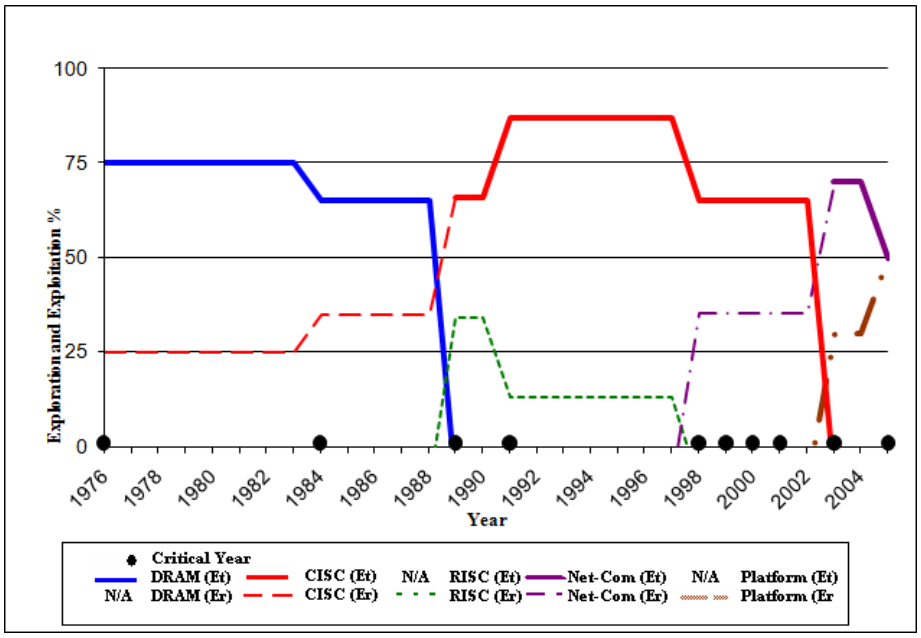
[7] See Burgelman and Grove (2007) Table 2.

[8] All figures are relative rather than absolute. Thus, while Intel may have increased its overall developmental expenditures over time, the percentages reported herein refer to relative proportions allocated to exploration and exploitation.

to exploration of CISC microprocessors to develop new CISC products using autonomous processes, thereby tilting the balance towards exploration. Thus, the ratio of exploration to exploitation changed from 25:75 to 35:65.

FIGURE 3.1

Intel's Developmental Resource Investments



Note: Et (exploitation) solid lines; Er (exploration) dotted lines.

By 1989, Intel was no longer investing its developmental resources in either exploration or exploitation of DRAM products. Instead, they had developed new CISC microprocessors, which were validated in the market, thereby changing the rules of the game in their favor. This prompted them to exploit the potential of their new CISC microprocessors using induced strategy to recover its developmental investments.

However, they also sensed that other industry players were promoting RISC microprocessors, which could threaten their new business of CISC microprocessors by changing the rules of the game against them. Hence, they were interested in an autonomous strategy of exploring the potential of RISC architecture by devoting part of their

developmental resources. As a result, they moved their exploration of RISC products to 34% and their exploitation of CISC products to 66%.

By 1991, their CISC microprocessors were thriving in the market and the threat posed by RISC microprocessors had declined. However, there were still some in Intel who were interested in continuing the exploration of RISC microprocessors, albeit at a lower level. Hence, they changed their balance of exploration (of RISC products) and exploitation (of CISC products) to 13% and 87%, respectively. Intel was in a virtuous cycle with its increasing clockspeed performance, sole-source strategy, and Intel-inside marketing campaign, among other competitive moves.

By 1998, with exploding market demand, Intel had finally chosen the CISC architecture and had abandoned exploration of RISC-related businesses.[9] In response to rule change by original equipment manufacturers (OEMs) from desktops to mobile personal computers (e.g., laptops and other devices), Intel *increased its exploration* by 22% (from 13% to 35%), by focusing on new CISC-related products for specialized network and communications microprocessors from 1998 to 2001. In other words, in 1998 their level of *exploitation* of CISC related products *decreased* by 22% (from 87% to 65%) and remained so until 2001. This exploration of specialized network and communications based products was successful, and helped the firm change the rules of competition in its favor. Consequently, it increased its exploitation of this new business by 5%, thereby investing 70% of its developmental resources to exploitation by 2003. In short, it decreased its allocation to exploration by 5%, reaching 30% of developmental resources devoted to platform-business related products (including extensions from network and communications related business).

Finally, in 2005, in response to increasing energy demands and excessive heat produced by their micro-processors, Intel shifted 20% of its developmental resources toward

[9] Intel never formally adopted the exploitation of the RISC architecture.

exploration of platform related business, reaching 50%, and thereby leaving the lowest ever proportion of their developmental resources—only 50%— for exploitation of microprocessor related business.

In a nutshell, Intel temporarily increases its exploration to generate variety-inducing autonomous processes (Siggelkow and Levinthal, 2003). This heuristic is different from the Cyclical heuristic in that neither exploration nor exploitation ever stop completely. From their experience, Burgelman and Grove (2007) derived two-part heuristic rules for the management of nonlinear strategic dynamics: First, when a firm (Pi) enacts strategies that change the rules of the game decisively in its favor, putting other stakeholders at a material disadvantage ("Pi-controlled change"), *exploitation* is the key to successful adaptation. Therefore, the firm should increase its balance towards exploitation to capitalize on its innovation. Second, when another firm changes the rules of the game in its favor, putting the focal firm (Pi) at a significant competitive disadvantage ("Pi-independent change"), the key to corporate longevity is *exploration*. Thus, the firm should increase its balance in favor of exploration to innovate.

Theory

Several mechanisms, which may be useful in explaining the inner-processes and relationships of systems, seem to be at work (Bunge, 2004; Hedström and Swedberg, 1998). Three mechanisms seem particularly important in explaining the relationship between balancing exploration and exploitation (strategic ambidexterity) and firm performance. These are: internal selection, which describes the evolution of the organization's internal environment (Burgelman, 1991); external selection, which describes how external stakeholders and customers dictate whether the firm will receive the factors it needs to

survive (Porter, 1980; Freeman, 1984); and strategic intent, which accounts for the role of leadership, rhetoric, and vision (Lovas and Ghoshal, 2000).

Internal Selection

Internal selection refers to that part of the internal ecology of organizations that determines whether a strategic initiative (e.g., exploratory projects) receives further investment or is cancelled (Burgelman, 1991). Strategic initiatives are sources of variation (McGrath, 2001) and constitute the units of selection within organizations, whereas organization members are the agents of selection (Lovas and Ghoshal, 2000). Organization members at different levels are attracted to projects that they believe will be more interesting, more successful, and more beneficial to their careers. This is especially true if members do not identify with the firm (Scott, 2007). As key personnel move laterally within the organization in search of the most rewarding work, they increase support for some strategic initiatives and starve others (Burgelman, 1991). Less exciting projects may be disbanded for lack of interest, resources, and capabilities, whereas attractive projects receive the attention and investment needed to grow. In short, internal selection refers to the resource competition between strategic initiatives inside of an organization.

External Selection

External selection refers to processes operating outside of the firm that determine the winners and losers in an industry (Hannan and Freeman, 1979; Jacobides and Winter, 2005). At this level of analysis, the units of selection are the firms themselves, whereas the agents of selection are the external stakeholders, such as investors and customers (Laplume, Sonpar, and Litz, 2008). For instance, customers determine which firms will thrive and which will not survive by buying the products of some and shunning those of others. As firms compete for customer transactions, those that produce attractive products are rewarded in the marketplace,

facilitating their survival. Firms that fail to produce attractive products may suffer losses, become insolvent, or be acquired.

Strategic Intent

Another important mechanism at play within organizations is strategic intent, which is a statement of vision or mission that guides the actions of members—the objective function of the organization (Prahalad and Hamel, 1989). Strategic intent is formulated by the top managers of an organization as they seek to guide the internal ecology of their organizations, helping them to adapt to changes in the external environment. For instance, a firm's strategic intent might be to beat the industry leader. As industry leaders are defeated, the industry is expanded, so that new leaders can be identified, and targeted.

Strategic intent is related to internal selection, in that top managers are also organizational members; However, it differs to the extent that the strategic intent of an organization exists independently from individual members (March, 1991). Through leadership, the intentional vision of key individuals in the firm may become engrained in most, if not all, of its members. Whereas individual agents may be out for themselves, strategic intent unites them in pursuit of organizational goals (Lovas and Ghoshal, 2000).

Incentive systems and other control systems help align individual interests with strategic intent. Strategic intent is teleological but flexible, as high-level goals may be adjusted in response to outputs, results, and experiences (Van de Ven and Poole, 1995). Strategic intent is a socialization mechanism that influences the perceptions of organizational members, guiding them in some directions and away from others. Executives steer the organization in directions deemed most promising by emphasizing some areas for optimization and downplaying others (Levinthal and March, 1993). Other mechanisms such as cooperation, conflict, fit, and networking may also operate in organizations.

Mintzberg (1991) argued that organizations can be viewed through many different lenses, including: political, lifecycle, cultural, cognitive, evolutionary, configurational, positioning, and design. Each lens uses a different set of mechanisms to explain phenomena. Van de Ven and Poole (1995) synthesized many different mechanisms into four motors: teleological, evolutionary, lifecycle, and dialectical. Various mechanisms are used to develop the hypotheses in the next section, however, with evolutionary and cognitive mechanisms at the forefront.

Hypotheses

This section develops hypotheses regarding the relationship between balancing exploration and firm performance in general, and under varying environmental conditions. Simulations and qualitative studies are meant to help the researchers evolve new extensions and elaborations of theory and to improve the internal validity of existing theoretical relationships (Eisenhardt, 1989). Instead of the usual term of "proposition" in simulation and qualitative studies, I use the term "hypothesis" in this thesis following a recent study (Siggelkow and Rivkin, 2009). Propositions tend to be more abstract statements of relationships between constructs, whereas hypotheses define more concrete relationships among variables (Bacharach, 1989). In short, while we use the term "hypothesis", the emphasis of this thesis is on theory development, not empirical testing.

Balancing Exploration and Exploitation

My starting assumption is that there is an inherent trade-off between exploration and exploitation in the organizational context. Unbalanced exploration and exploitation levels are

detrimental to firm effectiveness and efficiency[10]. Too little exploitation prevents an organization from riding down the experience curve through routinization and economies of scale. If a firm develops new knowledge but does not redirect resources toward exploiting it, it may obsolesce in incubation, be shelved and forgotten, or imitated by competitors (Levinthal and March, 1993). Exploiting too many new ideas simultaneously spreads resources too thinly. It may be better to focus, as well as reduce the complexity of trying to run many different businesses. All else being equal, executives may select businesses that are similar in some respects in order to conserve energy in trying to manage multiple logics simultaneously. An interesting point about Intel is that while it experimented with many different technologies, it tended to invested heavily in those that could sustain the entire weight of the company's resources and still turn a profit (Burgelman, 1991). In other words, it may not be worth the effort to develop an idea that cannot at least match the value of the current core business.

Incentive systems may also play an important role in resource allocation decisions within firms. Organizations with excessively loose structural control mechanisms and a lack of routinization may create a situation where members feel apt to take on particularly risky projects at the expense of those with more certain rewards. For instance, if the organization unknowingly rewards innovations that compromise efficiency (e.g., following fads and fashions with no merit in the hopes of a blockbuster discovery) members may choose to abandon projects at various stages of development, starving the abandoned projects of the resources needed to push forward and invest to produce commercial success. Therefore, incentives must not reward faddism, but, rather, be designed to reward options that are clearly not popular but that have not been demonstrated to be ineffective. Repeating mistakes

[10] This assumption creates a built-in bias against the Specialist heuristics. Firms employing the Specialist heuristic may survive by entering into alliances with complementary firms. However, such arrangements entail a blurring of firm boundaries which is outside of scope the current study.

is expensive, but taking new risks is a prerequisite for organizational performance over the long run (March, 1991).

Furthermore, the strategic intent of an organization may be too fuzzy or broad, failing to focus organizational members in specific directions. It may be difficult for them to understand a dual or triple logic (Bettis and Prahalad, 1995). As organization members perceive that the firm is no longer making good decisions and is headed toward failure, they may see their internal career prospects flicker and pursue risky projects that further their future career prospects outside of the organization, such as bleeding edge technologies that have not been sufficiently tested or validated but which appear to be in high demand elsewhere. This increases the chance that faddism will ensue, where changes are made for benefit of the agents rather than the firm (Abrahamson, 1991).

Doing nothing is usually better than repeating a mistake, but trying something new means going against the herd, and, moreover, trying something that isn't known to work or fail (Levinthal and March, 1993). Conversely, exploiting a business past maturity and into decline may leave the firm with falling revenues. Firms cannot derive competitive advantage from knowledge that has been made obsolete by new developments. Firms must continually shift their competencies in line with what is currently valuable knowledge in order to succeed in the marketplace. Customers are unlikely to buy from firms that do not keep their products up to date, as evidenced by the short product lifecycles in many industries.

In order to shift to new competences, organizations need to invest in exploration, which is a key source of variation in organizations (McGrath, 2001). The more a firm engages in exploration, the more likely it will innovate (Burgelman, 1991; March, 1991). Firms may fail to invest sufficiently in exploration for three key reasons. First, the *internal selection mechanism* within organizations may be underdeveloped. Tight restrictions on labour and resource mobility within organizations may dampen the internal ecological

processes inherent within them. Excessive controls and too little resource slack may prevent the generation of autonomous strategic processes, inhibiting the generation of promising new strategic initiatives (Burgelman and Grove, 2007).

Second, and just as likely, the *strategic intent* of an organization may further constrain its members by placing limits on member agency, by forcing them to pursue the interests of shareholders above their own. Too narrow a strategic intent may discourage organization members from pursuing new directions by increasing the perceived risk of deviating from the stated vision (punishment). They may avoid promising new directions because of fear that they will not be seen as valuable by senior managers.

Third, *external selection* kicks in, whereby external stakeholders remove their support from firms that do too much exploitation (e.g., newspaper companies, record companies, General Motors). They also shy away from firms that do too much exploration, as these are high risk ventures that may be best split up to have their risks shared by venture capitalists, rather than mutual fund holders.

In sum, inertial forces inside firms, limited strategic vision, and the demands of external stakeholders combine to suggest that there exists a trade-off between exploration and exploitation within organizations and that this trade-off can be modelled as an inverted U-shaped relationship with organizational performance (see Figure 3.4). This stands opposed to views of ambidexterity that discount the role of tradeoff between exploration and exploitation.[11]

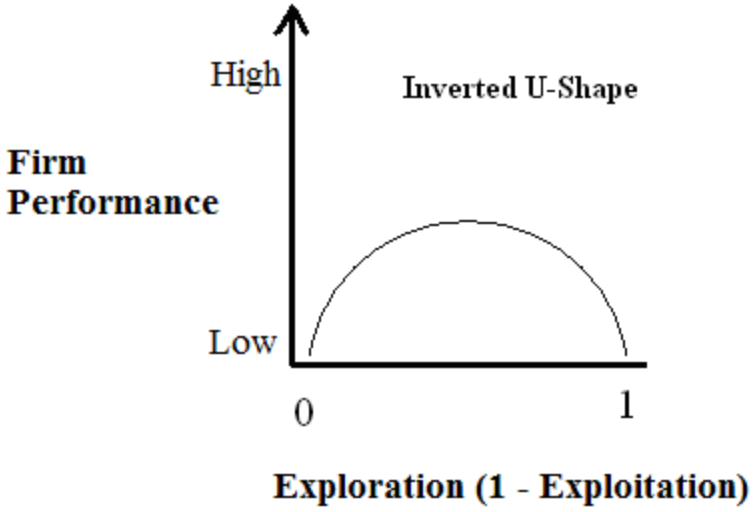
This inverted U-shaped relationship has been validated by empirical work (e.g., Katila and Ahuja, 2002; Laursen and Salter, 2006; Uotila et al., 2009). However, prior research has typically been limited to detecting the curve in data. Let us examine more closely the shape of the curve, that is, the shape of the distribution of the potential industry

[11] Curvilinear relationships can be measured with regression using a function.

earnings (Burgelman and Grove, 2007; Saloner, Shepard, and Podolny, 2001) in terms of rewarding some balancing strategies more than others. There are several different shapes that a U-shaped curve can take, four of which are depicted in Figure 3.5. A U-shaped curve may be skewed to the left or right, and be flat or tall.

FIGURE 3.4

Expected relationship between the level of exploration (1-exploitation) and firm performance

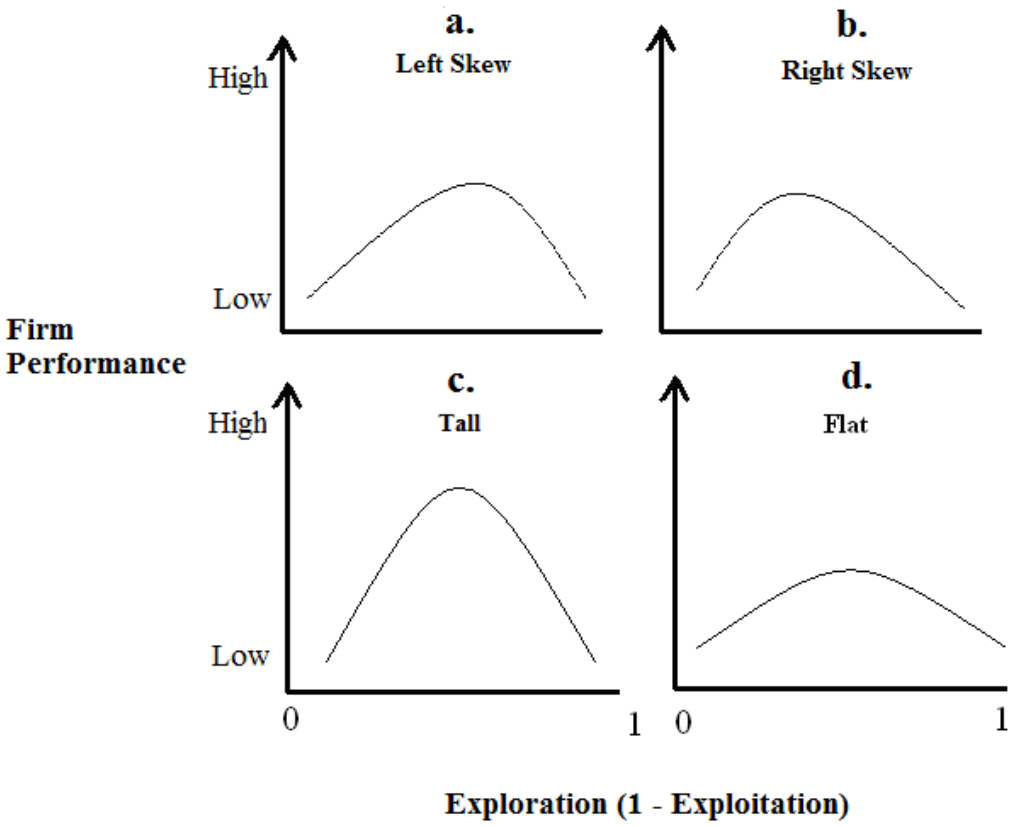


A *left skew* (Figure 3.5a) indicates that higher average levels of exploration lead to higher performance. A *right skew* (Figure 3.5b) indicates that lower average levels of exploration lead to higher performance. A *tall curve* (Figure 3.5c) indicates steep differences in performance from small differences between balance levels (i.e., a steep landscape). By contrast, a *flat curve* (Figure 3.5d) suggests an environment where the differential

performance of various balances of exploration and exploitation is small - nearly any strategy will do. The shape of the curve may be affected by different environmental conditions.

FIGURE 3.5

Some possible curves describing the relationship between level of exploration (1-exploitation) and firm performance



Type of Rule Change Environment (H1 and H2)

Rule changes refer to regulatory, technological, normative, cognitive, and economic changes to the way firms compete in an industry, favouring some and harming others (Burgelman and Grove, 2007). Rule changes may come about as a result of many smaller

changes, for instance, by creating a perfect storm, or by reaching a tipping point where larger changes may occur (Bettis and Prahalad, 1995).

Rule changes may be competence enhancing or competence-destroying for firms (Anderson and Tushman, 1990). Whether they help or hurt depends not on who invented the new rules, but, rather, who capitalized on them through innovation. Self-destructive innovations, such as cannibalizing the firm's existing business to support as less valuable replacement are largely prevented by savvy managers, as well as by market forces of valuation. Firm failures do not merely readjust market share between survivors, they also release resources to be used by new entrants (e.g., via human resource turnover). In some industries, destructive rule change is regulated with intellectual property rights, professional strictures, and other institutions (Scott, 1987). Highly institutionalized environments are more inertial, and, hence, more difficult to change (Hannan and Freeman, 1979). It takes a massive leap in performance to stimulate adoption of novelty in such a system.

Some industries are continually being undermined by destructive changes because every improvement of the core technologies lays waste to previous generations. For instance, while it may be difficult to imagine a new bed technology that sweeps the market, a doubling of computer speeds had, for a long time, been sufficient to stimulate the replacement of personal computers used by industry and by consumers. The older computers did not stop working, but they just could not do what the newer ones could.

Industries may also have experienced many opportunities for competence enhancing rule change with little destructive change. For instance, developments in technology make a website increasingly valuable. As the number of complementary investments made possible by the Internet exploded, it undermined some brick and mortar businesses, but it also enabled huge swaths of online ones. The mix of the force of both constructive and destructive types of rule change is expected to affect the firm's balance of exploration and exploitation. The

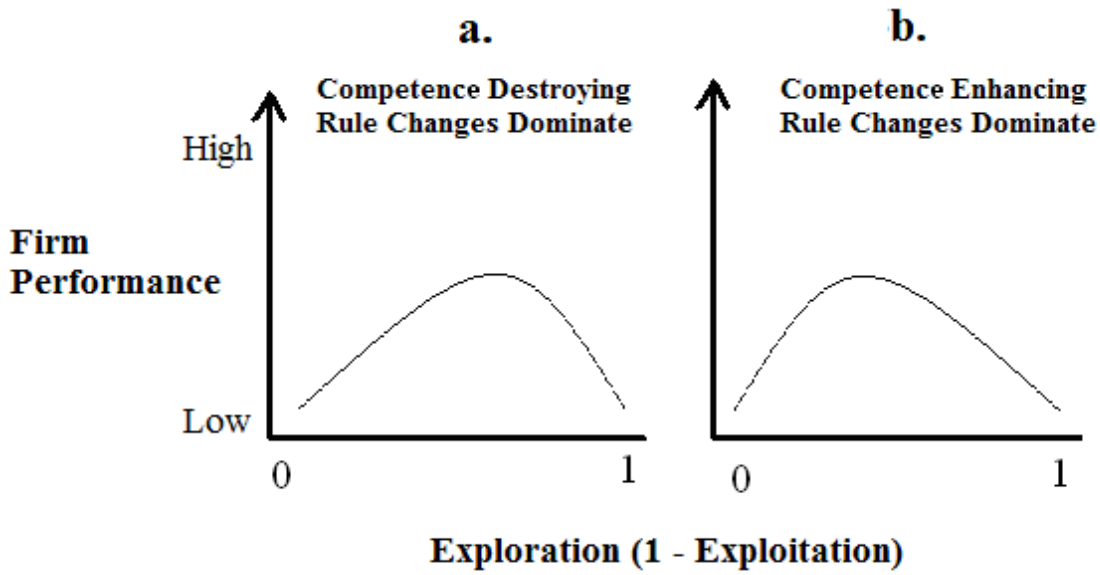
destructive force of competence-destroying rule changes may be balanced by an equally potent mix of competence enhancing rule changes.

Internal selection processes, manifesting in the movement of labour within organizations, tilts the curve to the right, increasing the value of exploration when competence-destroying rule changes force a firm to find new businesses to replace its dwindling undermined existing businesses. As members perceive their futures within the obsolescing core pessimistically, they may vote with their feet by supporting new projects that believe will succeed, including riskier ones.

The increase in performance is explained by the external ecology of the organizations. As firms compete for customers, they try to differentiate themselves through innovation and/or by lowering costs. Customers are more likely to be attracted to products at the edge of the price/innovation frontier (Porter, 1980). Competence-destroying rule changes shorten the useful life of products and their associated competencies, increasing the need for innovations to keep up with compressed lifecycles. Firms that do not keep up with the pace of change in the industry may lose out to more innovative competitors. External selection alters the mix of surviving firms in an industry, favouring those that closely reflect customer demands. Thus, the optimal level of exploration is expected to be higher when destructive rule changes dominate (Figure 3.6a). Conversely, an industry where competence enhancing rule changes dominate is likely to have a higher optimal level of exploitation, and a lower optimal level of exploitation (Figure 3.6b).

FIGURE 3.6

Competence enhancing and competence-destroying rule-change and the relationship between level of exploration (1-exploitation) and firm performance



Strategic intent may also reinforce the effect of external selection through conscious imitation. Managers compare themselves to higher-performing industry referents (Peteraf and Shanley, 1997). This comparison process may influence the firm's strategic intent, as it is reformulated in-line with the practices of more successful firms. In other words, as strategic leaders recognize that firms that do more exploration perform better in industries with more destructive rule change, they will be impelled to follow suit, adjusting the firm's vision, rhetoric, and incentive systems to enable more exploration. Whether or not they are making the right move may be partly self-fulfilling because when many firms increase their exploration simultaneously, they are likely to increase the potential for innovation (Levinthal and March, 1993)

Likewise, as strategic leaders recognize that firms that do more exploitation are more successful in environment dominated by competence enhancing rule changes, they may

increasingly act to constrain the firm's exploration. A narrower strategic intent may help to focus the organization on exploiting some of the abundant opportunities instead of looking to move on to new ones too quickly (March, 1991). When competence enhancing rule changes dominate in an environment, the firm does not need to do as much exploration because there are plenty of opportunities to enter new businesses if a competence-destroying rule change should occur. Rather, it should concentrate on doing more exploitation to make short-term gains. By contrast, a firm needs to do more exploration if competence-destroying rule changes dominate, as the life of the current business will shorten, and many more new opportunities will need to be developed in order for the firm to thrive.

> *Hypothesis 1a: The optimal level of exploration will be higher in environments where competence-destroying rule changes dominate.*
>
> *Hypothesis 1b: The optimal level of exploitation will be higher in environments where competence enhancing rule changes dominate.*

The type of rule change environment experienced by a firm is a function of the rate of knowledge obsolescence in its fields of endeavour (Schulz, 2003), which is itself a function of the aggregate exploration of firms in an environment (Levinthal and March, 1993). For instance, the obsolescence of one technology may be caused by the invention and diffusion of another (Schumpeter, 1939). Thus, as firms increase or decrease their exploration levels, they also contribute to the rate of change in their industry, accelerating or decelerating rule change frequency. However, I have argued that it is the overall tendency of the environment toward competence enhancing or competence-destroying rule change that should determine a firm's strategic ambidexterity heuristic.

Rule changes favour some firms while harming others. This is implicit in the definition of competitive advantage and in notions of gaining a larger share of potential

industry earnings (Burgelman and Grove, 2007). In environments dominated by *competence enhancing* rule changes, strategic leaders should incrementally capitalize on opportunities, but maintain a Regular rhythm of investment (Brown and Eisenhardt, 1997). Strict control of exploration avoids the failure trap of becoming overwhelmed by new ideas (Levinthal and March, 1993, March, 1991), especially in an environment where competence-destroying rule changes are sparse, making the abandonment of current competencies superfluous (D'Aveni, 1999; Jansen et al., 2006).

Conversely, environments dominated by *competence-destroying* rule changes continually disrupt current competences, requiring firms to respond by dramatically shifting their resource allocations between exploration and exploitation. The extent of this shift will depend on the degree of potential impact of rule changes on the firm, its products, customers, and profits. In an environment that has few competence enhancing rule changes and high competence-destroying rule changes, strategic leaders should enact periodic *revolutions* in the form of Cyclical ambidexterity, moving from one extreme to the other (Hamel, 1996; D'Aveni, 1999).

A firm might divert a small, medium or large percentage of its developmental resources toward or away from exploration or exploitation activities in response to a given rule change. As we have seen, Intel maintained a balance of exploration of between 13% and 50% (exploration) over 30 years (see Figure 3.1). However, Burgelman and Grove (2007) give little guidance regarding the amount to change, other than to say that increments ought to be "significant", while decrements (i.e., vectoring) ought to be "material". Predicting the optimal range, increments, and decrements in the balance of exploration and exploitation may be an important dynamic capability that may distinguish successful firms from others (O'Reilly and Tushman, 2008; Venkatraman et al., 2007). Over time and with experience, strategic leaders of a firm are likely to develop insights, judgments, heuristics, and

capabilities for anticipation and change, as per their intent of developing strategic ambidexterity. I anticipate that the size ratio of increments to decrements of the Irregular heuristic ought to roughly reflect the number of potential rule-changes in the environment. For example, all other things being equal, in an industry with two similar firms, the number of rule changes by the firm and its competitor is likely to be equal. Likewise, all other things remaining the same, for a firm with four competitors similar to itself in size and other capabilities, the ratio of endogenous rule changes to exogenous (independent) changes is likely to be 1:4.

The effectiveness of the three ambidexterity heuristics—Regular, Irregular, and Cyclical—may depend on their match with the industry environment due to the mutual-reinforcement of the three mechanisms of external selection, internal selection, and strategic intent.[12] Tempering responses to the industry's idiosyncratic patterns prevents firms from overshooting and undershooting optimal levels of exploration and exploitation. As customers are accustomed or entrained (Ancona and Chong, 1996) to a particular pattern of novelty, they may be unimpressed by innovations that differ from their expectations. Overshooting (e.g., Volantis' mobile software tools, Apple's Newton, Friendster, and Sony's Betamax) may result in innovations that are ahead of their time, and are rejected by cautious customers. Undershooting (e.g., Google's Wave) may produce underwhelming innovations that fail to attract sufficient customer attention.

Within the organization, the internal selection mechanism is at play. As members experience patterns of change over time, they may learn to scale their experimentation in line with the environment (i.e., matching customer expectations). They may also experience

[12] We make no predictions regarding the specialist heuristics because specialization may not be possible without close cooperation with complementary partners (i.e. someone to explore and someone else to exploit innovations from the former). Given that such alliances entail the blurring of firm boundaries, they may be operationally subsumed by one of the other heuristics.

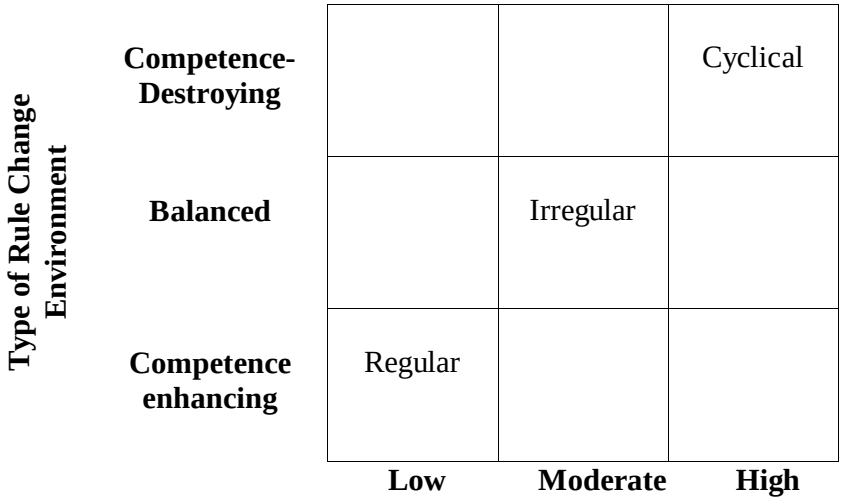
institutional pressures leading to cognitive and normative conformity (Suchman, 1995). They may perceive experiments that are unusually ambitious as high-risk and, therefore, avoid them. Similarly, they may avoid insufficiently ambitious projects, believing them to be inconsequential given the size of extant rule changes in the industry. Given some degree of mobility, organization members at various levels are likely to select projects that they anticipate will be successful or balance risk and rewards favourably (Lovas and Ghoshal, 2000). As a result, the roster of exploratory projects in an industry may become increasingly homogeneous.

Strategic leaders may modify the strategic intent of the organization to match their perceptions of the external environment. They may constrain exploration within a particular range that they believe to be suitable given the frequency and type of change in their industry. For instance, if the norm in the industry is for firms to set long-term innovation goals and to invest in multi-year research projects, managers may modify the strategic intent of the organization to be more ambitious. In short, strategic leaders may reinforce the patterns of change in the industry.

Figure 3.7 suggests that the conditions under which each heuristic is differentiated by its range (i.e., the difference between its maximum and minimum level of exploration [1-exploitation]) will dictate whether it performs better than others. As seen in Figure 3.7, the Cyclical heuristic may be particularly well-suited to environments with competence-destroying, quantum rule changes. Such rule changes, when internally generated, may require firms to divert a large amount of its resources to exploiting the innovation, especially if there are capable imitators in the industry (i.e., fast followers). By avoiding extreme shifts, the Regular heuristic may be better suited to environments with frequent competence enhancing rule changes.

FIGURE 3.7

Type of rule change environments and ambidexterity heuristics



A competitive marketplace is a dialectic between entrepreneurial endeavors, corporate or otherwise, and the destruction of organized competencies that ensue (Schumpeter, 1939). Changes that are competence enhancing for a firm may also be destructive toward others. When the rate of destruction exceeds the rate of creation, then it may be best to cycle between structures, processes and routines, and the more uncertain organizational behaviors of entrepreneurship, play, and risk-taking. Exploration that dislodges firms from their prior evolutionary trajectories may enable firms to avoid competency traps (Siggelkow and Levinthal, 2003). For instance, Venkatraman et al. (2007) found support for a sequential approach to ambidexterity in the highly dynamic software industry. Cycling between exploration and exploitation allows a firm to cash in on its *core* with short bursts of maximum investment, followed by periods of minimal investment, to focus on its eminent replacement. Short generations of competencies do not make them

worthless, but they require a quick harvest that only the Cyclical approach can provide, with its periods of pure exploitation. The cash generated, if it is not restored to investors, can then fund exploration for a new business. If the gap between the end and the next beginning is short enough, survival is ensured, although the size and makeup of the organization needed may change.

By contrast, if we assume a world where there is more creation than destruction, then longer generations of competencies are implied, and the best strategy is to maintain a level rate of exploratory investment. The need to cease investing in the core business is reduced, because long generations imply diminishing returns to exploitation. Instead of extracting every bit of value from the business as quickly as possible, it may be better to maintain a constant level of investment in exploration. This may defer profits, spreading them over a longer time span, but it helps to ensure survival by creating a pipeline of new business to choose from when existing ones are destroyed or unprofitable.

The middle ground, a world where creation and destruction are roughly in balance, calls for a heuristic with the advantages of cycling and staying regular. The Irregular approach, of which Intel is a good example, allows the firm to switch emphasis between exploration and exploitation, increasing the former more gradually than the latter, but never eliminating either activity completely (Burgelman and Grove, 2007). This creates both a pipeline, although a more limited one, and also allows for the bursts of exploitation needed to capitalize on shorter competence generations. Together, these insights suggest the following hypotheses:

> *Hypothesis 2a: The Regular heuristic will outperform others in environments with high competence enhancing and low competence-destroying rule changes.*
>
> *Hypothesis 2b: The Irregular heuristic will outperform others in environments with moderate competence enhancing and competence-destroying rule changes.*

Hypothesis 2c: The Cyclical heuristic will outperform others in environments with low competence enhancing and high competence-destroying rule changes.

Level of Competitive Intensity (H3 and H4)

Competitive intensity in a product-market represents "the *set of products* judged to be substitutes" (Day, Shocker, and Srivastava, 1979: 10; emphasis in original). Thus, competitive intensity refers to the proportion of purchase alternatives that buyers consider and compare to select the best supplier to buy from. Some industries may experience more competitive intensity than others. For example, customers may consider only a proportion of their suppliers as relevant (DeSarbo, Grewal, and Wind, 2006; Griprud and Gronhaug, 1985; Porac and Thomas, 1990).

The intensity of competition in an industry may affect a firm's optimal level of exploration (1-exploitation) through the mechanisms of external selection, strategic intent, and internal selection. External selection determines the winners and losers in an industry according to the buying behavior of customers. Firms that cannot muster the support of a minimal number of customers will fail to gain economies of scale and ride down the experience curve, potentially putting them at a fatal disadvantage vis-à-vis competitors. Competitive intensity increases the power of external stakeholders (Porter, 1980). Simply put, if there are more competitors to choose from, customers have more power, as do investors and bankers. When more firms compete on the same dimensions it is more difficult for them to differentiate themselves from the crowd. Consequently, stakeholders may find it easier to compare products and to choose among the best.

Firms may fail to develop knowledge on the key dimensions that external stakeholders use to decide between multiple similar alternatives. Stakeholders have little

difficulty recognizing the superior quality products when all firms are considered in their decision processes. However, if the customers are not even aware that a particular firm exists, then it can hardly be expected that they will consider its products in their decisions.

Inside the organization, the internal ecology is at play. Increased competition is likely to motivate search behaviour on the part of organizational members. For instance, members may seek to move to parts of the organization that create value that customers appreciate. Weaknesses of the organizations become exposed as the customer's blindfold is removed. Those parts with fatal weaknesses will need to explore to save themselves.

Strategic intent is also likely to shift into a "focus mode" as top managers perceive that the level of competitive intensity is increasing and that differentiation based on dimensions they were once competent in is now worthless. As vision and rhetoric narrow in on the dimensions where the focal firm is lagging or leading others, incentives can be shifted to reward exploitation of the "right" dimensions, and to suppress exploration of the wrong ones.

In sum, when competitive intensity is low, customers are less able to differentiate among competitors. In such a situation, any strategy is likely to work and the performance differences across firms will be lower. When competition increases, firms that exploit and explore "just enough" will be more likely have higher performance. Competitive intensity is likely to exaggerate the differences between "optimal" and "sub-optimal" exploration and exploitation balance levels. The distribution of firm performance by level of exploration should therefore be taller (Figure 3.8a) in more competitive industries, whereas environments with low competitive intensity are likely to flatten or dampen (Figure 3.8b) the effect of different levels of exploration on firm performance. Accordingly, I hypothesize that:

> *Hypothesis 3a: The shape of the distribution of firm performance by the level of exploration (1-exploitation) will be taller in more competitive industries.*

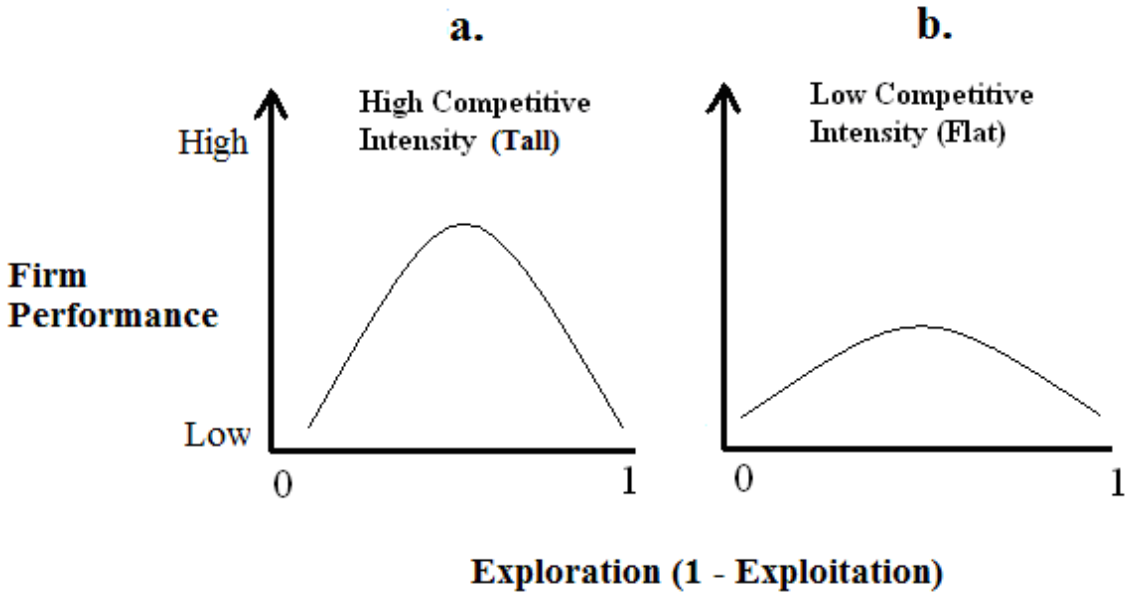
Hypothesis 3b: The shape of the distribution of firm performance by the level of exploration (1-exploitation) will be flatter in less competitive industries.

As previously noted, external selection is a key mechanism in determining the performance of firms. Environments with high levels of competitive intensity have more firms competing on the same knowledge dimensions, producing a convergence between the capabilities and strategies of firms. When many firms compete on the same dimensions it may be easier for customers to compare products, hence selecting those with higher levels of quality. By contrast, environments with low levels of competitive intensity have fewer firms competing on a given knowledge dimension, allowing for a high degree of divergence between the strategies and knowledge of firms. This is also how it is modeled in the simulation and what appear to be present in the case.

Customers are more likely to be attracted to products at the edge of the price/innovation frontier. Competitive intensity increases the potency of rule changes. Customers are better able to select better performing products, shortening the useful life of existing products and competencies by causing laggards to stand out and be ignored.

FIGURE 3.8

The effect of competitive intensity on the relationship between level of exploration (1-exploitation) and firm performance



This increases the need for innovations to keep up with compressed lifecycles. However, competitive intensity also increases the risk involved in innovation, as new products that lack luster are more likely to be rejected or ignored. Innovations that are misguided or ineffective are less likely to be purchased and their producers are less likely to be rewarded for their efforts. Thus, under high competitive intensity, external selection alters the mix of surviving firms in an industry, favoring those that closely reflect customer rationality about product quality.

Inside the organization, the internal selection mechanism is at play. When competitive intensity is low, members are likely to get rewarded for any pattern of change, irrespective of the quality of their product offerings. The lack of incentives for making the superior products may reduce the need to make radical changes in response to rule changes,

dampening the differential effectiveness of the ambidexterity heuristics and increasing status quo inertia.

Conversely higher competitive intensity magnifies the difference between optimal and sub-optimal exploration and exploitation balance levels and associated heuristics. Competitive intensity is expected to moderate the relationship between ambidexterity heuristics and firm performance under varying levels of types of rule change environments. These effects are also likely to be reinforced by strategic intent, as strategic leaders modify the vision and goals of the organization to match more successful referents. This leads to the following hypothesizes:

> *Hypothesis 4a: Competitive intensity will increase the degree to which the Regular heuristic will outperform others in environments dominated by competence enhancing rule change.*
>
> *Hypothesis 4b: Competitive intensity will increase the degree to which the Irregular heuristic will outperform others in environments where competence enhancing and competence-destroying rule changes are balanced.*
>
> *Hypothesis 4c: Competitive intensity will increase the degree to which the Cyclical heuristic will outperform others in environments dominated by competence-destroying rule change.*

Proactive Versus Reactive Switching (H5)

This section makes predictions about the effectiveness of proactive versus reactive switching between exploration and exploitation, for the Irregular and Cyclical heuristics.[13] Rule changes may include commoditization (i.e., as a result of the adoption of radical new process technologies, such as TQM), exclusive contracts, novel marketing campaigns, and new technologies (Burgelman and Grove, 2007). Others have identified financial shocks, stakeholder bankruptcies, executive successions, and changes to top management

[13] We make no predictions regarding the Regular heuristic as it involves a very narrow range of change in exploration/exploitation and does not involve switching.

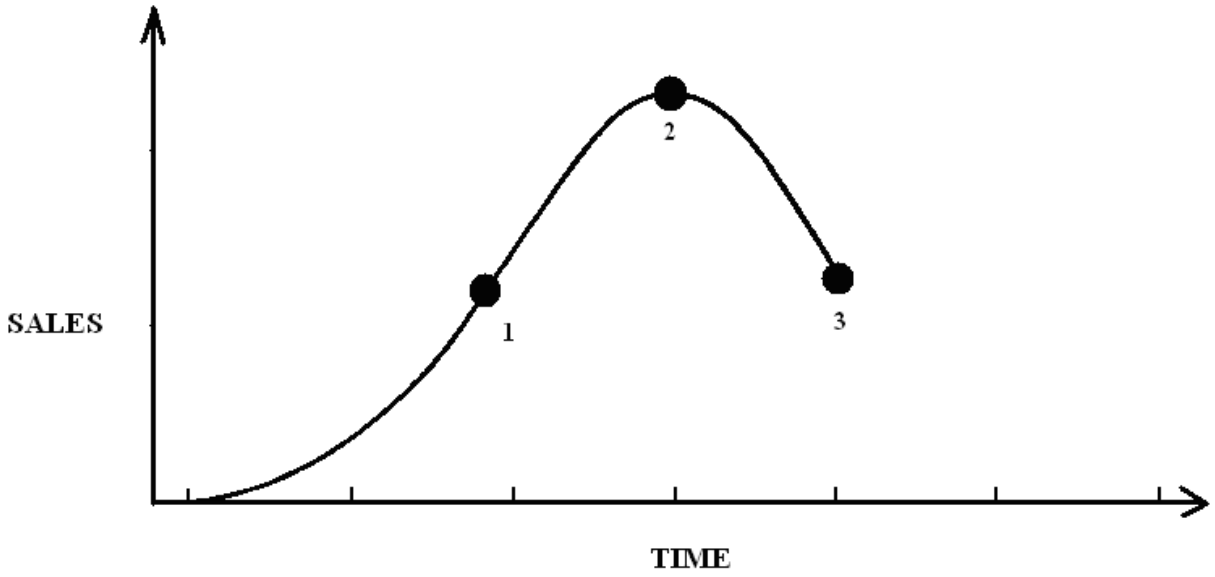
conceptions of the external environment as key triggers for rebalancing exploration and exploitation levels (Lovas and Ghoshal, 2000; McNamara and Baden-Fuller, 1999).

However, some changes may be more proactive, while others are more reactive. If a rule change begins at t_i and ends at t_{i+1}, then $t_{i+1} - t_i$ is the duration of the change. The beginning can refer to the first intuition of an innovative idea, its expression to a group, the moment a team actually gets to work on it, or the instant it produces value for customers or influences consumer sentiment. The end refers to the moment a change's full effects have been metered out, that is, all actors to be affected materially by the change have been.

Proactive switching occurs near the beginning of a rule change, whereas waiting until near the end of a rule change is reactive switching. For instance, responding to signals that the rules of competition have changed early is more proactive than responding to poor performance that results from it. Actual rule changes are caused by the innovations of firms, but perceived rule changes are moments of strategic recognition occurring within the strategic leadership of organizations; i.e., the moment the team realizes that the rules of the game have changed, but before its full material effects have occurred (Burgelman and Grove, 2007). By contrast, reactive change occurs when strategic leaders miss, ignore, or disbelieve key rule changes. A change based on the recognition of poor performance in terms of financial measures or market share is reactive because the changes that created the poor performance have already left their mark. For instance, as depicted in Figure 3.9, if Point 2 is the point of inflection between the growth and decline of a particular product innovation, then starting exploration around Point 1 is more proactive, while starting at Point 2 (the inflection point from growth to decline or half-life of the innovation) or Point 3 (mid-decline) is more reactive.

FIGURE 3.9

Three points in the product lifecycle



Organizations that switch proactively may perform better than those using time and resources in collecting highly accurate knowledge (Sutcliffe and Weber, 2003). Therefore, rules that are too complex or need a longer time to collect and process data (thereby slowing firms' responses to opportunities and threats) may not be advantageous for them. On the other hand, the effect of rule changes may take time to materialize or the results may vary from firm expectations. Switching too proactive may be treacherous for firms if their early perceptions of rule change do not solidify into actual rule change.

Change may be led by rank-and-file members of organizations in addition to top managers (Burgelman, 1991). When members lower in the organizational hierarchy perceive change ahead of top management, they may respond by actively switching projects within the organization (i.e., lateral movement) with the hope of landing in more successful streams. Rewards tend to go to those on successful projects such that each individual's unique placement in the organization may determine the rewards of participating in the organization.

For instance, the top talent of an organization may be drawn to the "sexiest" projects, leaving "doomed" projects to those who cannot see the coming peril.

Organizations such as Intel and Oticon are designed to allow free movement of human resources within their organizations, taking advantage of internal ecological processes (Burgelman and Grove, 2007; Lovas and Ghoshal, 2000). However, whereas Oticon required exploratory projects to be sponsored from a senior manager from inception, Intel allowed exploratory initiatives to evolve independently from top management scrutiny, selecting them in or out, depending upon their potential during latter phases, i.e., after a gestation period of autonomous development. For instance, Burgelman (1991) describes how unauthorized strategic initiatives can grow to consume considerable organizational resources before top managers have extended formal support (i.e., becoming part of Intel's induced strategy).

In conclusion, although two firms may follow the Irregular or Cyclical heuristic, they may do so differently by switching between exploration and exploitation proactively or reactively. I reason that, on balance, switching proactively may be more effective than responding to reactively because the latter entails more information gathering delays than the former. Switching proactively amounts to taking pre-emptive action before the full consequences of a rule change have materialized (i.e., nearer to Point 1 in Figure 3.9). Reacting to poor performance by increasing exploration amounts to a desperate bet, pulling resources away from exploitation at a time when they may be needed most (i.e., nearer to Point 3 in Figure 3.9), potentially speeding up decline. Thus, other things being equal:

> *Hypothesis 5a: The Irregular heuristic will perform better with proactive switching than with reactive switching.*
>
> *Hypothesis 5b: The Cyclical heuristic will perform better with proactive switching than with reactive switching.*

Level of Product Diversification (H6)

The qualitative study conducted as part of this thesis developed a moderating role for product diversification. As the firm I studied (ABC Inc.) increased its product diversification, it also became increasingly regular in its approach to strategic ambidexterity. The firm's chief executive regularly remarked that the firm had nearly infinite opportunity for new product/business development and that the problem was in selecting among them and allocating resources between them. Meanwhile, very few competence-destroying innovations were perceived by the firm, evidenced by their reluctance to drop more antiquated product models from their catalogue. I developed an extension to theory based on these qualitative findings and a review of the product diversification literature.

The importance of diversification theory to strategic management is evidence by the considerable attention the topic has attracted. Too much diversification is problematic for firms (Chandler, 1966; Rumelt, 1974; Ramanujam and Varadarajan, 1989; Stimpert and Duhaime, 1997). Territorial expansion dilutes the contact between organizational members while it brings diverse knowledge to the firm. Product expansion into vertically unrelated markets generates diversity of ideas and opinions. Vertical integration can also increase product diversification once competencies created for internal are leveraged for third party business in new markets.

Too little diversification is also problematic for firms, as having all of one's eggs in the same basket is the classic problem of modern finance and portfolio theory. Diversification reduces market turbulence in returns, by investing in counter cyclical businesses, but, more consequentially, it reduces product or technological turbulence by reducing the impact, if not the number, of rules change. Rule changes occur when there is a tipping of advantage from some firms to others. They can be categorized according to a material technology,

psychological, or institutional views (Burgelman and Grove, 2007), but are largely reducible to each other. What they all share in common is that when they occur, some of firms suffer losses while others gain.

From a cognitive perspective, the environment is akin to executives' perceptions or visions of their future environments, which may vary depending on their strategic intents and the level of product diversification of the firm. Executives realize their strategic visions by adopting strategies that match their perceived environments (e.g., Hamel, 1996; D'Aveni, 1999; Lovas and Ghoshal, 2000). Those executives in diversified firms, especially in unrelated businesses that have incompatible logics (Bettis and Prahalad, 1995), are likely to interpret their environments as more complex (Rivkin, 2000), and may find it difficult to make sense of them (Weick, 1979).

The problem of balancing exploration and exploitation can be reduced to the diversification problem. In order to create steady growth, a pipeline of future businesses must constantly be generated to replace those being undermined by rule changes in the environment (March, 1991). The firm must continually explore opportunities to change the rules of the game in their favour, or at least to stay on the winning side of the key plays. The firm can either work to prolong its current businesses by incrementally improving them, or accept their inevitable demise and move on to other things, that is, if they have invested enough to have new opportunities to move on to. Making a desperate bet based on a short time experience may result in catastrophe for the firm, while brewing the new business and trying it out in test markets before they are needed is expensive, but important (Burgelman and Grove, 2007).

Only when there are so many destructive rule changes in the environment that no one can get ahead is a Cyclical approach to strategic ambidexterity warranted (D'Aveni, 1999). So long as competence enhancing, status quo maintaining rule changes more than make up

for competence-destroying revolutions (Tushman and Anderson, 1990), incumbent organizations can make hay by diversifying in a regular fashion. When this relationship is reversed, new entrants get the upper hand, using Cyclical ambidexterity strategies to enter the game.

It follows that, as firms increase their level of product diversification, they can increase their performance by following Regular ambidexterity heuristics. Since product diversification implies an expansion of relevant environments for the firm, which may be largely unrelated, the potency of rule change in one of them will be dampened for the whole. Therefore, the firm need not make as dramatic a move into exploration when just a part of its competence is destroyed. For instance, when a firm competes on price in a single line of products, in a single geographical market, it is competing on only one dimension at a time. As it expands its territory and adds additional product lines, it must also develop new systems and structures to cope with the diversity of environmental factors that enter into play. Assuming that rule changes are limited to just one dimension at a time, more dimensions implies that each rule change has a smaller impact on the firm's overall knowledge. For instance, institutional rule changes in one geography may be counter-balanced by those in other territories. Similarly, if competence with one set of technologies is undermined by a new diffusing invention, it may not affect business in other lines. Likewise, competence enhancing rule change in one market or product line may not spread to the others. Over time, changes would be smaller in proportion to the firm, and more easily counter-balanced by opposing changes in different parts of the organization. In short:

> *Hypothesis 6: The performance of the Regular Heuristic will increase with the level of product diversification of the firms.*

This chapter introduced four strategic ambidexterity heuristics (Specialist, Regular, Irregular, and Cyclical). Using various mechanisms (e.g., external selection, internal

selection, and strategic intent), I developed hypotheses about the effect of environmental moderators (type of rule change environments and competitive intensity) and organizational moderator (proactive versus reactive and diversification), on the optimal level of exploration and the differential performance of the heuristics. A summary of the hypotheses developed in this chapter in Table 3.1.

Table 3.1

Summary of Hypotheses

#	Hypothesis
1a	The optimal level of *exploration* will be higher in environments where competence-destroying rule changes dominate.
1b	The optimal level of *exploitation* will be higher in environments where competence enhancing rule changes dominate.
2a	The Regular heuristic will outperform others in environments with high competence enhancing and low competence-destroying rule changes.
2b	The Irregular heuristic will outperform others in environments with moderate competence enhancing and competence-destroying rule changes.
2c	The Cyclical heuristic will outperform others in environments with low competence enhancing and high competence-destroying rule changes.
3a	The shape of the distribution of firm performance by the level of exploration will be taller in more competitive industries.
3b	The shape of the distribution of firm performance by the level of exploration will be flatter in less competitive industries.
4a	Competitive intensity will increase the degree to which the Regular heuristic will outperform others in environments dominated by competence enhancing rule change.
4b	Competitive intensity will increase the degree to which the Irregular heuristic will outperform others in environments where competence enhancing and competence-destroying rule changes are balanced.
4c	Competitive intensity will increase the degree to which the Cyclical heuristic will outperform others in environments dominated by competence-destroying rule change.
5a	The Irregular heuristic will perform better with proactive switching than with reactive switching.
5b	The Cyclical heuristic will perform better with proactive switching than with reactive switching.
6	The performance of the Regular heuristic will increase with the level of product diversification of the firms.

CHAPTER IV: METHODOLOGY

Simulation Methods

This section justifies and describes the methods used for this thesis: computer simulation and a field study. I selected methods that compensate for a lack of large datasets covering temporal heuristics for strategic ambidexterity, and which provide additional benefits such as theory elaboration to an area of research in its early stages of theoretical development. The mix of methods selected is well-suited to the study non-linear phenomena (Anderson, 1999; Burgelman and Grove, 2007).

While databases of patents and accounting measures may be available, these proxies hardly do justice to the heuristics operating tacitly in the minds of managers and other organizational members. Where firms focus their attention over time may eventually be reflected in investments in specialized equipment and human resources, but accounting measures of research and development do not differentiate between projects that are exploratory or exploitative in nature (Burgelman and Grove, 2007). Patent data may be categorized based on citation novelty (Katila and Ahuja, 2002), but for most organizations, patents are unavailable, a minor part of, or irrelevant to the variety of initiatives they may be involved in.

The problem of data availability might be solved with repeated surveys over long periods of time (He and Wong, 2004), however this solution is infeasible for thesis work. March (1991) distilled several words into exploration and exploitation, including play and experimentation, and routine and improvement, respectively. Thus, counting keywords in annual reports or other public organizational communications may go a long way toward capturing a reflection of managerial attention (Uotila et al., 2009), even if it may miss the context in which exploration and exploitation ensue.

Moreover, temporally based heuristics for strategic ambidexterity involve change triggers that may be tacit to firm members. Measures of sequential patterns of exploration and exploitation using specialized longitudinal datasets may allow for effective categorization (Venkatraman et al., 2007), but cannot account for the heuristics firms used to decide when to change (i.e., proactively or reactively) and how much to change.

To overcome these limitations, I developed a computer simulation to examine the performance of various ambidexterity heuristics. Unlike statistical methods, which are cumbersome for measuring all but the most basic non-linear interactions, simulations can easily accommodate non-linearity (Anderson, 1999). Simulation is particularly justified when empirical data are challenging to obtain because they involve excessive longitudinal measurement or complex process phenomena (Davis et al., 2007a; Rudolph and Repenning, 2002). Management and organizational researchers have demonstrated the usefulness of computer simulations for developing and elaborating theory (e.g., Rivkin, 2000; Sastry, 1997; Siggelkow and Levinthal, 2003). Given that current interest in the topic of balancing exploration and exploitation among scholars was stimulated by March's (1991) agent-based computer simulation (O'Reilly and Tushman, 2008), further extension through simulation modeling seems well-justified.

Simulation methods are particularly effective for research where there exists a basic outline of theory, but where underlying theoretical logic is limited (Davis et al., 2007a). Burgelman and Grove's model of strategic dynamics is at an early stage of theoretical development. Indeed, they introduce several new terms without suggesting their operationalization. For example, they write that increments in exploration should be "significant", while decrements (i.e., vectoring) should be "material". They also introduce terms that have not been fully integrated into current theory. For instance, they refer to strategic recognition as the ability to spot rule changes, but do not develop the concept

beyond Grove's (1996) earlier conception of paranoia. Nonetheless, this work does provide a sufficient basis for developing a simulation to examine its internal consistency, reliability, and boundary conditions (Cook and Campbell, 1979).

I adapted core ideas from March's (1991) agent-based simulation, and its extension by Miller et al. (2006), but made firm level agents and added customer agents. I considered using an NK-fitness landscape (Caldart and Richart, 2007; Holland, 1975; Kauffman, 1993; Siggelkow and Levinthal, 2003), for instance, by modelling exploration and exploitation as local and global search, and redrawing parts of the landscape to simulate rule changes. However, the standard NK solution does not allow me to test competing heuristics together in an environment they are actively affecting (competitive dynamics). It also would not allow attribution of rule changes to specific firms according to their endogenous exploration levels (see Lee and Ryu, 2002). More importantly, since the Irregular and Cyclical heuristics require that firms increase or decrease their levels of exploration in response to rule changes, but differently depending on who made the change, attribution becomes key.

Custom simulations offer flexibility at the expense of standardization (e.g., March, 1991; Miller et al., 2006; Davis et al., 2007b). However, they employ familiar building blocks (e.g., Gaussian distributions, Markov chains, S-curves, random number generators, loops, interactions, states, landscapes, and processes), making them more understandable to a wider audience.

The simulation is agent-based (Davis et al., 2007a; Harrison, Lin, Carroll, and Carley, 2009; Sastry, 1997; March, 1991), and was written using a popular high level programming language (Visual Basic 6.0). It entails stochastic processes such that the simulation never produces exactly the same results twice (Davis, et al., 2007). Complex adaptive systems, such as organizations, are often modeled with agent-based simulations. Anderson (1999) described several characteristics of complex adaptive systems, which apply in this context. First, they

involve aggregations of agents with simple schemata and rules, which interact together to produce complex outcomes at more than one level of analysis (e.g., individual, firm, and industry). The interaction between agents is modelled as dependencies and feedback loops, causing the agents to affect one another. Thus, the system as a whole changes as a consequence of lower level adaptation, i.e., rules generate structure as the output of the application of the rules becomes the input for subsequent applications. Complex adaptive systems are dynamic systems (whose state at time t determines its state at time t+1) that do not reach either a fixed-point or cyclical equilibrium. Their processes are not random, but chaotic, revolving around attractors in a deterministic way that seldom, if ever, returns to the same state. The behaviour of the system can be greatly affected by initial conditions, which can cause the system to tip between chaotic equilibria. They are characterised by self-organization, evolving from random starting states toward order. The following sections are intended to describe the features of the simulation in enough detail to allow for replication. Further details can be obtained by contacting the author.

Components and Knowledge Structure

A primary design goals was to simulate Burgelman and Grove's (2007) model of strategic dynamics. To this end, the basic model components are generic Producer firms and Customer firms (the agents).[14] Each firms has an organizational code, represented by its total knowledge (March, 1991), or justified beliefs (Nonaka, 1994). The Producer firms race across a simple two dimensional knowledge landscape. Exploration increases the number of dimensions in a firm's knowledge structure, whereas exploitation increases the depth of knowledge a firm's attains in a given dimension of its knowledge structure. This design reflects work by Katila and Ahuja (2002), who distinguish between search depth, defined as

[14] A more elegant design is to have the agents be both customers and the producers, but this requires a larger pool of firms to enact a typical environment and is left to future research.

the degree to which search revisits a firms' prior knowledge, and search scope, defined as the degree of new knowledge that is explored. It is also functionally similar to Stuart and Podolny's (1996) description of local versus universal search, and evolutionary versus revolutionary change (Tushman and O'Reilly, 1996).

For most of my experiments, I fixed the number of dimensions that firm's can develop knowledge in to five, reasoning that single business organizations may pursue only a moderate number of contingencies at a time. For a concrete example, a firm producing a micro-processor could improve its knowledge along four dimensions, such as decreasing size (e.g., depth of five inches to only a inch), enhancing speed (e.g., depth from one to 5,000 megahertz), reducing cost (e.g., depth of 50 dollars per pound to 10 for silicone), and increasing energy efficiency (e.g., depth of reducing energy use to a watt from 50). Conversely, it may be the first to put multiple micro-processors on the same board, representing a path-breaking change along a new dimension requiring software to be rewritten to accommodate multiple cores.

However, I increased the number of knowledge dimensions available to firms in order to simulate different levels of product diversification. Diversified firms may compete on more knowledge dimensions because of the increased variety of contingencies involved with running multiple businesses, especially if they are unrelated (Chandler, 1966; Rumelt, 1974). Thus, by increasing the number of knowledge dimensions upon which the firms can compete, I was able to test hypotheses about the effects of product diversification.

Heuristics

I also modeled each agent's internal ecology as a dialectic between autonomous (exploration) and induced strategic processes (exploitation). Specifically, each firm has a level of exploration between 0 and 1 that determines its balance. At each iteration of the

simulation, each Producer firm acts according to its current balance of exploration and exploitation. For instance, a firm with an exploration level of 0.2 will explore during 20% of the simulation iterations and exploit during 80% of the iterations. Each exploration attempt was given a one in twenty[15] chance of successfully opening a new knowledge dimension for the firm. This reflects the finding that exploration is rarely successful (Levinthal and March, 1993); for example, Stevens and Burley's (1997) research suggests that small exploratory projects within corporations have a small chance of becoming commercially successful. Once a firm opens a dimension by exploration, it becomes available for exploitation. Exploitation adds depth (i.e., +1) to the firm's knowledge along a previously explored knowledge dimensions.[16] I allowed exploitation attempts to succeed according to a regime of diminishing returns, such that it becomes increasingly difficult to exploit a given dimension as it develops[17]. In a nutshell, at a given iteration, each firm gets a turn, which it can use to try to broaden or deepen its knowledge.

When a Producer firm opens a new dimension of knowledge for itself, it changes the rules of the game. This event is modelled as trigger for other Irregular or Cyclical heuristics firms to implement switching (Burgelman and Grove, 2007). Each rule change can be considered to be competence enhancing for the firm that initiated it, i.e., opening a new dimension for it to exploit. However, in order to make rule changes competence-destroying, I set a proportion of competitors' knowledge along the affected dimension to zero. The

[15] The field study of ABC Inc. suggested that, in some industries, exploration can have a much higher occurrence of success. Higher and lower rates of innovation were also tested, but these did not affect the qualitative results of the simulation; rather, changing this parameter merely alters the speed of the simulation. The actual probability of innovation is also a function of the collective exploration of the firms in the simulation because the more firms explore, the more likely that innovations will occur.

[16] At the start of the simulation, a firm cannot exploit a knowledge dimension unless one has been opened by exploration.

[17] For all of our reported experiments, we fixed the rate of diminishing returns such that the probability that subsequent exploitation will add knowledge depth is reduced by one divided by the total knowledge depth of the firm on that dimension.

affected proportion is another parameter set at the start of the simulation to control the type of rule change environment.

The simulation is scalable, such that any number of firms can be used to run experiments. For all the experiments reported herein, the simulation ran with five firms using each heuristic: firms 1-5: Regular heuristic; firms 6-10: Irregular heuristic; and firms 11-15: Cyclical heuristic.[18] Although some industries may be more fragmented than others and thus have more firms in play, changing the number of firms is not expected to affect the results as long as the number of customers and the increment of the Irregular heuristic are calibrated accordingly.

To maintain a balanced simulation, I set the starting level of exploration of the Irregular firms to the same level as their ordinal Regular counterparts. For instance, Firm 6's level of exploration equalled Firm 1's, Firm 7's matched Firm 2's level, and so on. I then set the minimum and maximum range of the Irregular firms 50% higher and 50% lower, respectively, than this initial level of exploration. The Irregular firms were also programmed to oscillate to their minimum levels of exploration in response to their own endogenous rule change. As there were 15 firms competing, exogenous change is 15 times more likely than endogenous change. Thus, I programmed the Irregular heuristic to increase its exploration to its maximum in increments of 1/15th of their range in response to rule change by another firm. In other words, the Irregular firms increase their exploration incrementally, but increase their exploitation all in one shot, consistent with vectoring an organization (Burgelman, 2002; Burgelman and Grove, 2007). The Cyclical firms were programmed similarly, but without increments, and with a minimum of zero and a maximum of 100 percent exploration.

[18] Future research may examine asymmetric allocations of firms, for instance, examining the effect of having on large firm using Regular ambidexterity and a large number of smaller firms using Cyclical or Irregular ambidexterity.

Competition and Performance Measurement

At each iteration, the Customer firms buy products from the Producer firms.[19] Each Customer firm buys from the firm with the most superior knowledge to its own. This increases the successful Producer firm's performance by an increment of 1 point and increases the Customer firm's knowledge to match the superior dimensions of the Producer firm. A Customer firm is more likely to buy from a Producer firm if the difference between the Customer firm's knowledge and the Producer firm's knowledge is the highest among all the firms examined. To illustrate, imagine three firms, each with three knowledge dimensions, each with varying levels of depth. For example, C1's dimensions 1, 2, and 3 are at the depths of 0, 10, and 5, respectively. Let's assume that depth may vary on a scale of 0 to 20. Then 0 represents the slowest speed of a microprocessor, whereas 20 reflects the highest speed. C1 is more likely to buy from P1 than P2 as the difference between C1 and P1 them is 2, whereas the difference between C1 and P2 is -9.

	Dimensions				
	1	2	3		
	Knowledge Level				
C1	0	10	5		
P1	3	8	6		
P2	1	1	4		
	Difference				
P1-C1	3	-2	1	=	2
P2-C1	1	-9	-1	=	-9

Competitive intensity was manipulated by changing the number of Producer firms the Customer firms scan in making their purchase decisions (Day, Shocker, and Srivastava, 1979). For instance, an environment where customers only examine 10% of the producers when deciding what to buy is less competitive than one where all of the producers are

[19]We assume that a firm's products, resources, and capabilities are a reflection of their knowledge.

examined. More comparisons make for more accurate buying decisions, making it harder for producers with less competitive products to make sales.

All experimental results report the average performance of the heuristics after 100 runs of 18,250 iterations.[20] An iteration of the simulation can approximate any length of time, such as a day, month, or year. Considering each iteration equivalent to a day, I chose to run 50 simulated years or 50 x 365 = 18, 250 iterations for all experiments. I also ran alternative tests for 25 and 100 simulated years and the results of the simulation did not vary.

The simulation generates a distribution of results which can be analyzed statistically to confirm hypothesized patterns in them (Ganco and Agarwal, 2009; Harrison et al., 2007). Sales performance for a given Producer firm was calculated by counting the number of times Customer firms bought from it over the course of the simulation. Sale revenues are an adequate and parsimonious measure of performance for the purposes of this study.

Simulation Limitations

This section outlines some limitation of simulation studies that apply to this research. Firstly, all methodologies have limitations; simulation is no exception. Simulations are often criticized for being "toy models" that strip away much of the complexity of real world phenomena by making simplifying assumptions, thus reducing their external validity (Davis et al., 2007a). Computer programs may seem too disconnected from reality to make valid inferences from them. By definition, all models are simplifications of reality for the purpose of explaining and predicting relationships between phenomena.

However, this does not diminish the role of simulations for internal validation and theory elaboration (Cook and Campbell, 1979; Sastry, 1997). As Davis and associates put it,

[20] Although we show the t-test results for the full sample in the Results chapter, they are not highly sensitive to aggregation. For instance, all the results reported herein remain qualitatively the same and statistically significant, whether there are 150 or 1500 firms competing.

the "computational rigor of simulation forces precise specification of constructs, assumptions, and theoretical logic that creates strong internal validity" (Davis et al., 2007a: 495). Similarly, Adner, Pólos, Ryall, and Sorenson (2009) argue that simulations are powerful tools for ensuring precision and transparency, checking logical consistency, and discovering unanticipated implications of theory.

Agent-based simulations allow emergent behavior at multiple levels of analysis and are useful for modeling complex interactions. However, the presence of too many interactions can make the simulation as complicated to understand as reality itself, confounding inferences from its results. Thus, an agent-based simulation cannot model more than a few interactions at a time without becoming obtuse or opaque to its creator (Adner et al., 2009). In this case, I limited the variables of interest to make sense of the model's behavior, and I acknowledge the possibility that additional variables can make a difference, e.g., imitation, mutual forbearance, and absorptive capacity.

Another potential weakness of custom simulation methods is that replication can be difficult because programming languages and algorithms are not part of the typical doctoral curriculum in management (Harrison et al., 2007). Researchers often hire professional programmers to write the code that implements their designs. This is similar to the use of paid research assistants in the context of experimental design, or the employment of interviewers in survey research. Moreover, the sprawl of programming languages that has occurred in recent years makes comparison even more difficult. In this case, I developed the simulation and wrote the code myself, which may have minimized the problems in translating theory, research, and methodology ideas into the simulation's design and architecture.

Finally, it is possible that even agent-based simulations, where the focus is on the emergent interaction, may be intentionally or unintentionally structured to validate hypotheses. Moreover, the choice of variables to explore out of a large set of possibilities

might allow for potential bias. These limitations of simulation research helped to motivate the use of mixed methods.

Qualitative Study Methods

In order to gain insights from direct contact with an organization, this research was informed by a field study of a longstanding locally headquartered medium-sized (revenues = $300 Million Canadian) private company. Qualitative data were gathered between November 2009 and April 2010. The firm was selected by asking several colleagues to supply examples of the most innovative firms in the region. After a preliminary analysis of secondary data on three often-mentioned firms, I selected the most innovative firm in the most competitive environment. The firm also met the criteria of continually growing its market share while also remaining profitable.

Contact with the company was initiated through the coordinator of the Asper School's Associates Program, and access was requested by the primary investigator. After a preliminary meeting, the firm's Chief Operating Officer agreed to sponsor the project. I was given open access to company employees, including the Chief Executive Officer, and to the firm's archive of internal documents.

Once access was established, the next step was to identify the executives that would be best to interview. A snowball method was used to expand the sample within the firm, i.e., asking interviewees to recommend others with different or complementary knowledge about organizational activities. Table 4.1 lists the organizational members and stakeholders that were interviewed individually, or informed the research through informal discussions or were observed during meeting, tours, and presentations. Scheduled interviews averaged one hour in duration and were used sparingly in order to

TABLE 4.1

Interviewees and their association with Pi

Organization Member or Stakeholder	# Individual Interviews	# Informal Discussions	# Meetings and Presentations Observed
1. Chairman and Chief Executive Officer	2	8	15
2. President and Chief Operations Officer	3	10	7
3. VP of Marketing and Chief Information Officer		2	4
4. VP of Product Engineering	1	1	1
5. VP of Sales		1	
6. VP of Operations	1	1	1
5. Two Plant Managers		3	1
6. VP Sales		1	
7. Director of International Business Dev.		1	2
8. VP and Division General Manager		1	1
9. Research and Development Manager		2	3
10. Application Engineering Manager		1	1
11. Product Development Manager			1
12. Design Engineering Manager		2	1
13. Product Designer			1
14. Division Operations Manager		2	2
15. Software Developer		1	
16. Executive Assistant		5	
17. Key Customer	1		
18. Various Customers		10	

minimize the use of informant's time. Informal discussions ranging from five minutes to an hour were used most frequently, catching informants between meetings, in hallway conversions, or en route to various locations.

The first stage of the research involved a review of the company's archive of internal documents. I was provided with an office space within ABC Inc.'s headquarters and given unlimited access to the archive going back nearly 50 years. Materials reviewed included: 1) company newsletters, which gave an appreciation of the historical business context of the firm, 2) employee shareholder reports, which provided detailed financial information and executive summaries of company activities, 3) presentation materials used for various purposes to highlight company initiatives and strategies to outside stakeholders, 4) product catalogs, which helped to increase my understanding of the firm's products and technologies, 5) product training videos, which gave me a deeper appreciation of the technological domain, 6) listings of the capital expenditures of the firm, and 7) a company history written by the

Chief Executive Officer spanning the first 40 years of the firm. Three weeks were dedicated to reading and analyzing these documents, which amounted to thousands of pages of text. Photocopies of key materials were made and notes were taken in the form of a chronology of events.

Next, several key meetings were attended and observed. These included 12 focused strategic initiative review meetings detailing the progress of innovation projects and outlining their next steps. Annual budgeting meetings were also attended, requiring travel to two different geographical locations. These meetings provided an overview of company results, operations, plans, challenges, and opportunities. Travel and collocation with company managers allowed a high level of access on a semi-casual basis for four full days and three evenings. During this period, relationships were developed with organizational members while dozens of informal discussions informed the research. Notes were kept of conversations with managers, employees, and customers.

Tours of two of ABC Inc.'s factories were taken in order to better understand the products and manufacturing processes of the firm. Three tours of ABC Inc.'s research and development laboratories also allowed for a greater understanding of the firm's product development capabilities. Four company presentations to outside stakeholders including bankers, business associates, and customers were observed. A full day was also spent with a group of customers who were attending a professional development workshop organized by ABC Inc. Finally, two social events with customers were also attended, allowing for informal discussions with several of ABC Inc.'s customers.

The primary goal of the field study was to assess the ambidexterity approaches and related heuristics the company used over the years for balancing exploration and exploitation. A spreadsheet containing a listing of all of the company's strategic initiatives was developed and incrementally improved during interviews and informal discussions. Initiatives were

classified as either exploration or exploitation based on the insights and opinions of informants. This was analogous to inductively deriving themes in order to make within-theme and between-theme comparisons (Eisenhardt, 1989).

Another goal of the qualitative study was to establish face validity for concepts such as proactive versus reactive switching, autonomous exploration, maximums, minimums, decrements, increments, and balance levels discussed herein. Establishing face validity was especially important given that the simulation was designed based upon secondary sources, such as empirical results, qualitative cases, and theory. Relying on secondary sources alone may be risky as they may be too context-specific to be useful, subject to misinterpretation, or filtered by the questions and purposes of their creators. For instance, autonomous strategic processes may be more or less effective at producing innovation in small and large organizations. The qualitative findings helped me to develop the concept of ambidexterity heuristics and their component parameters, and to refine the design of the simulation, which in turn generated theoretical extensions that follow from the model. For instance, Hypothesis 6 examines the role of product diversification on a firm's strategic ambidexterity approach, and was developed as a direct result of the qualitative study.

This qualitative work also generated insights about how to measure ambidexterity heuristics within archival data or survey instruments. For instance, given the informal nature of autonomous strategic processes, they are largely omitted from balance sheet and income statements, confounding the use of accounting-based databases such as Compustat. They are not fully accounted for in the capital expenditure of firms; even if capital expenditures could be classified as exploratory or exploitative, they do not capture the substantive movements of human resources within the firm. However, one could examine the type of professions being hired from in a given year, if these data were available. For instance, when a manufacture hires a drafter, programmer, or graphics designer for the first time, it is likely developing

something new. However, competencies can also be acquired simply by re-tasking existing flexible resources, such as engineers from process to product technologies.

Field studies have well-known limitations with regard to generalizability and replication (Eisenhardt, 1989), which will not be examined in detail here. Qualitative analysis is appropriate given that my goal for the qualitative analysis was to bring clarity to the abstractions of the simulation through grounded theory building within a rich context, and to extend theory.

CHAPTER V: RESULTS

This chapter deals with the results of the simulation and of the qualitative analysis of the field study data. First, I present the simulation results for each of the hypotheses, and supplemental analyses to establish boundary conditions and conduct robustness checks. Each hypothesis required a different configuration of the simulation, as well as different charts and descriptive statistics. I used the results of statistical tests to explicate the results. Second, I elaborate the results of my qualitative study of a successful business firm. I used a combination of interviews, observation, and document analysis to derive the firm's pattern of strategic ambidexterity, and to validate and develop new hypotheses about balancing exploration and exploitation.

Hypothesis Tests

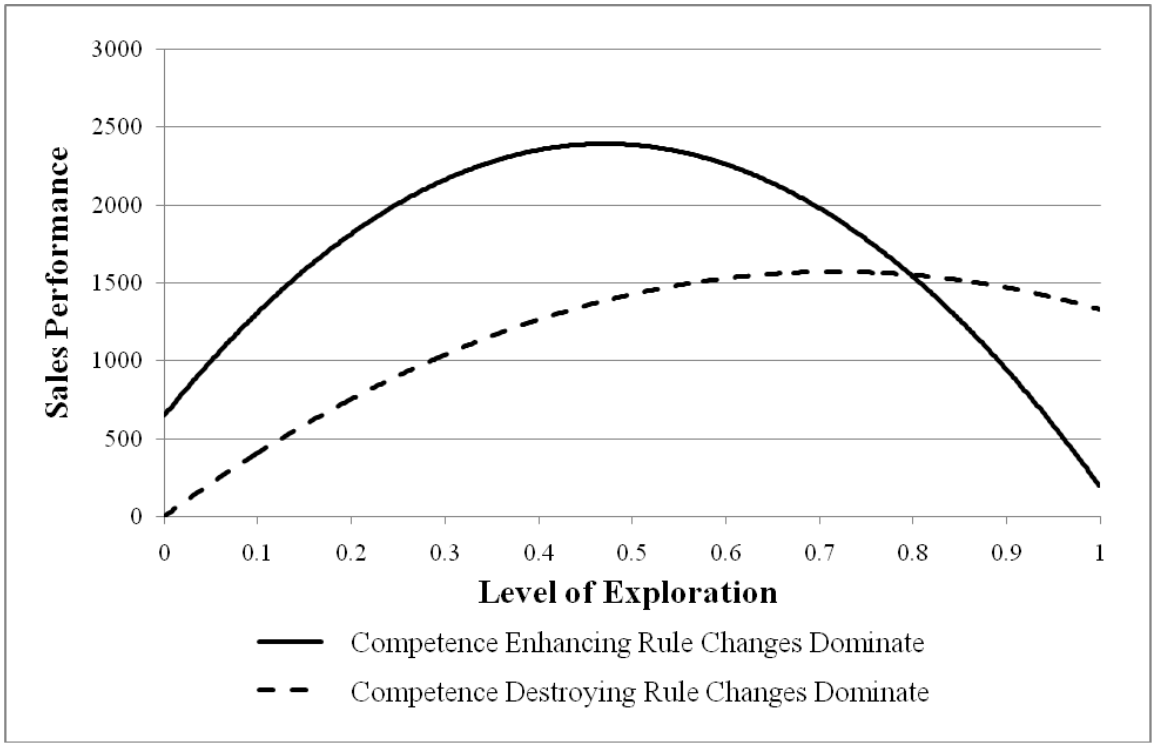
Hypothesis 1

In order to test Hypotheses 1, which relates to the optimal level of exploration in varying rule change environments, I ran two experiments with five firms using only the Regular heuristic. Since the hypothesis pertains to a specific balance of exploration and exploitation that is fixed over time, the dynamic heuristics (Cyclical and Irregular) were not considered in the analysis. For these experiments, I kept the level of *competence enhancing* rule change at 5%, meaning that one in 20 exploration attempts produced a competence enhancing rule change. I then varied the level of *competence-destroying* rule change from high (100%) for the first experiment to low (5%) for the second experiment. In percentage terms, in the first experiment with high competence-destroying change, 100% of firms lose their knowledge when the rules change. However, in the second experiment with low competence-destroying rule change, only 5% of firms lose their knowledge when the rules

change. The resulting curves and sales performance for the Regular heuristic under both conditions are provided in Figure 5.1. The curves in this figure show the tradeoff between exploration and exploitation. Firms had rising sales performance as their level of exploration increased, but then started to decrease afterwards. This is the inverse U-shaped relationship.

FIGURE 5.1

Firm performance by level of exploration varying rule changes



As can be seen in Figure 5.1, when competence-destroying rule changes were dominant, the simulated firms increased their exploration, shifting the optimal level of exploration to the right (from around 0.45 for when competence enhancing rule change dominates to about 0.71 when competence-destroying rule change dominates), confirming Hypothesis 1a. When competence enhancing rule changes were dominant, the firms

decreased their exploration, shifting the optimal level of exploration to the left, confirming Hypothesis 1b. In short, this supports my contention that benevolent (competence enhancing) environments may make exploration easier, and therefore reduces the need for it. Likewise, environments characterized by competence-destroying innovations force firms to undertake more exploration, all other things being equal.

Hypothesis 2

In order to test Hypotheses 2 about the optimal ambidexterity heuristics varying rule changes, I ran three experiments with five firms using each of these heuristics: Regular, Irregular, and Cyclical. For these experiments, I kept the level of competence enhancing rule change at 5%, meaning that one in 20 exploration attempts produced a competence enhancing rule change. I then varied the level of competence-destroying rule change from high (100%) for the first experiment, moderate for the second (25%) experiment, and low (5%) for the third experiment. In percentage terms, high competence-destroying rule change means 100% of the competitor firms lose their knowledge on the affected dimension. When competence-destroying change is moderate, 25% of firms lose their knowledge on the affected dimension upon the advent of rule change. When competence-destroying change is low, only 5% of firms lose their knowledge when the rules change. I report results using these three illustrative levels of competence-destroying rule change, but additional tests indicated that the results remain the same when competence-destroying rule change affected between 0% and 15% (low), 16% and 37% (moderate), and 38% and 100% (high) of the competing firms.[21]

Hypothesis 2a proposed that the Regular heuristic would outperform others in environments with *high* competence enhancing and *low* competence-destroying rule changes.

[21] The relationship between the heuristics and type of environment is non-linear.

As shown in Table 5.1a, the p-value from the Analysis of Variance (ANOVA) test was statistically significant. The mean sales performance of the Regular heuristic was 1735.4 with a standard deviations (S.D.) of 764.8, the Irregular heuristic's mean sales performance was 1600.5 (S.D. 580.3), and the Cyclical heuristic's mean sales performance was 314.1 (S.D. 217.3) The differences between the mean of the Regular heuristic and those of the other two heuristics were statistically significant, as confirmed by t-tests (Table 5.1a), supporting Hypothesis 2a. As Table 5.1 reveals, the performance of the Irregular heuristic was better than that of the Cyclical heuristic.

Hypothesis 2b predicts that the Irregular heuristic would outperform others in environments with *moderate* competence enhancing *and* competence-destroying rule changes. As shown in Table 5.1b, the p-value from the Analysis of Variance (ANOVA) test was statistically significant. The mean sales performance for the Irregular, Regular, and Cyclical heuristics were 1518.2 (S.D. 527.3), 1427.4 (S.D. 615.4), and 704.4 (S.D. 266.1), respectively. The differences between the mean sales performance of the Irregular heuristic and the mean sales performance of the other heuristics were statistically significant as confirmed by t-tests, therefore supporting Hypothesis 2b. Table 5.1b also reveals that the Regular heuristic performed better than the Cyclical heuristic.

Hypothesis 2c anticipates that the Cyclical heuristic would outperform others in environments with *low* competence enhancing and *high* competence-destroying rule changes. The p-value from the Analysis of Variance (ANOVA) test was statistically significant (Table 5.1c). The Cyclical heuristic's mean sales performance was 1262.2 (S.D. 246.6), whereas the mean for the Irregular and Cyclical heuristics were 1205.4 (S.D. 483.2), and 1182.5 (S.D. 475.2), respectively. The t-tests comparing the mean sales of the Cyclical heuristic to those of the Regular and Irregular heuristics confirm that the differences were statistically significant,

supporting Hypothesis 2c. I may note that there was no significant difference between the sales of the Regular and Irregular heuristics under this condition.

TABLE 5.1

Heuristic sales performance under varying rule change conditions

Competence enhancing Rule Change Dominates (a)					
Regular		**Irregular**		**Cyclical**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
1735.4	764.8	1600.5	580.3	314.1	217.3
				ANOVA	P < 0.000
Comparisons		**T-Test**		**Winner**	
Regular vs. Irregular		0.001		Regular	
Regular vs. Cyclical		0.000		Regular	
Irregular vs. Cyclical		0.000		Irregular	
Competence enhancing and Destroying Rule Changes in Balance (b)					
Regular		**Irregular**		**Cyclical**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
1427.4	615.4	1518.2	527.3	704.4	266.1
				ANOVA	P < 0.000
Comparisons		**T-Test**		**Winner**	
Regular vs. Irregular		0.007		Irregular	
Regular vs. Cyclical		0.000		Regular	
Irregular vs. Cyclical		0.000		Irregular	
Competence-destroying Rule Change Dominates (c)					
Regular		**Irregular**		**Cyclical**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
1182.5	476.2	1205.4	483.2	1262.2	246.6
				ANOVA	P < 0.007
Comparisons		**T-Test**		**Winner**	
Regular vs. Irregular		0.222		Irregular	
Regular vs. Cyclical		0.001		Cyclical	
Irregular vs. Cyclical		0.010		Cyclical	

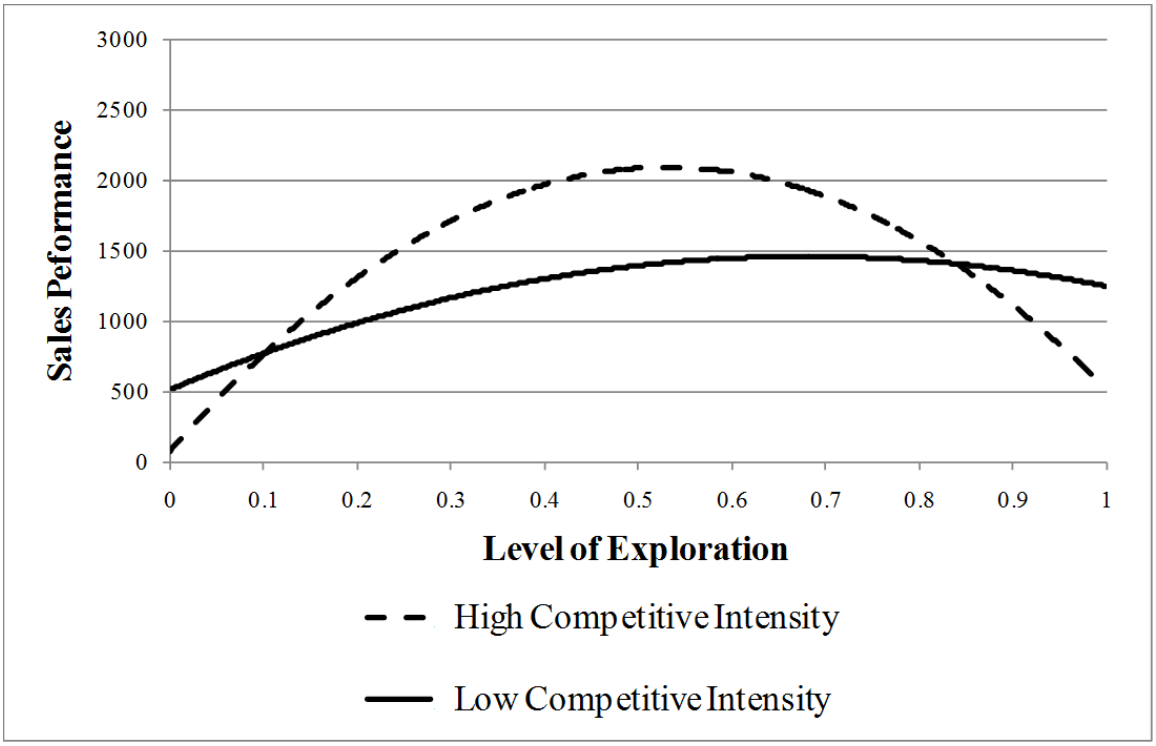
Hypothesis 3

In order to test Hypotheses 3, I ran two experiments, each with five firms using the Regular heuristic. For the first experiment, I set the level of competitive intensity to low (5% buyer scan). For the second experiment, I set the level of competitive intensity to high (100% buyer scan). I manipulated competitive intensity by changing the number of Producer firms the Customer firms scan in making their purchase decisions. The more firms scanned, the higher the competitive intensity.

Hypothesis 3a predicted that the inverted U-shaped curve of the relationship between the firm's levels of exploration and its performance will be taller in industries with high competitive intensity. Hypothesis 3b showed that the curve would be flatter in industries with low competitive intensity. The differences between the curves in Figure 5.2 demonstrate this. The curve for high competitive intensity is taller than the curve for low competitive intensity, supporting Hypothesis 3a. Conversely, the curve for low competitive intensity is flatter than the curve for high competitive intensity, supporting Hypothesis 3b.

FIGURE 5.2

Firm sales performance by level of exploration varying competitive intensity



Hypothesis 4

In order to test Hypotheses 4, I ran two experiments, each with 15 firms; five using each of the three heuristics (Regular, Irregular, and Cyclical). For the first experiment, I set the level of competitive intensity to low (5% buyer scan). For the second experiment, I set the level of competitive intensity to high (100% buyer scan).

Hypothesis 4 argued that increasing competitive intensity would magnify the performance differences among the heuristics without changing the underlying relationships between the heuristics' environmental performance. When competitive intensity was low (Table 5.2a), the p-value of the ANOVA test was only significant at 0.051. The t-tests confirmed that the Irregular heuristic performed best, with mean sales of 1227.3 (S.D. 253.6),

but the differences between it and the Regular heuristic, with means of 1226.9 (S.D. 276.5), was no longer statistically significant.

TABLE 5.2

Heuristic sales performance varying competitive intensity

Low Competitive Intensity (a)					
Regular		**Irregular**		**Cyclical**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
1226.9	276.5	1227.3	253.6	1195.7	122.7
				ANOVA	P < 0.051
Comparisons		**T-Test**		**Winner**	
Regular vs. Irregular		0.491		Irregular	
Regular vs. Cyclical		0.016		Regular	
Irregular vs. Cyclical		0.007		Irregular	
High Competitive Intensity (b)					
Regular		**Irregular**		**Cyclical**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
1518.3	615.3	1586.3	526.2	545.4	223.9
				ANOVA	P < 0.000
Comparisons		**T-Test**		**Winner**	
Regular vs. Irregular		0.030		Irregular	
Regular vs. Cyclical		0.000		Regular	
Irregular vs. Cyclical		0.000		Irregular	

However, the Irregular and Regular heuristics remained superior to the Cyclical heuristic with mean sales 1195.7 (S.D. 122.7), as confirmed by the t-test. Under high competitive intensity (Table 5.2b), the ANOVA p-value was statistically significant ($p < .000$). The t-tests revealed that the Irregular heuristic had a mean sales performance of 1586.3 (S.D. 526.2), which was statistically significantly higher than the mean sales performance of the Regular heuristic of 1518.3 (S.D. 615.3) and 545.5 (S.D., 223.9) for the Cyclical heuristic. Together, these results support Hypothesis 4b.

I also replicated the same results for the condition where competence enhancing rule changes dominate and where competence-destroying rule changes dominate (see Figure 5.1).

In both cases, the results were the same, that is, the level of competitive intensity did not change which heuristic was superior, but simply reduced the performance gap between the heuristics.

Hypothesis 5

Hypothesis 5 argued that the firms would perform better with proactive than with reactive heuristics. The two heuristics that involve change are the Irregular and Cyclical heuristics. In order to test Hypothesis 5, I constructed two new heuristics: the Reactive Irregular heuristic and the Reactive Cyclical heuristic to test Hypotheses 5a and 5b, respectively. These new heuristics use changes in sales performance to decide when to increase or decrease exploration. I created two variations of the Irregular heuristic, as presented in Figures 5.3 and Tables 5.3.

FIGURE 5.3

Reactive Irregular heuristics

(a)	(b)
When sales performance increases from one period to the next, increase exploration to the maximum; When sales performance decreases, decrease exploration to the minimum.	When sales performance increases from one period to the next, decrease exploration to the minimum; When sales performance decreases, increase exploration to the maximum.

TABLE 5.3

Proactive versus Reactive Irregular heuristics performance

(a)				(b)			
Proactive		**Reactive**		**Proactive**		**Reactive**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
1412.0	486.7	794.7	343.1	1441.6	426.8	752.3	280.4
T-Test		**Winner**		**T-Test**		**Winner**	
0.000		Proactive		0.000		Proactive	

In Figure 5.3, I two variations of the Reactive Irregular heuristic: (a) *increases* exploration to the maximum in response to *increases* in sales performance from one period (i.e., one simulated year) [22] to the next and *decreases* exploration to the minimum in response to *decreases* in sales performance; (b) *decreases* exploration to the minimum in response to *increases* in sales performance from one period to the next and *increases* exploration to the maximum in response to *decreases* in sales performance. Version (a) may be used by firms that believe the way out of a reduction in sales is through rapid exploitation and the way to capitalize on a sales increase is to explore. By contrast, version (b) may be used by firms that want to explore their way out of a declining sales situation, and increase exploitation when sales rise. Thus, (b) is more reactive than (a), but both are more reactive than the Irregular heuristic because they rely on sales, which is a lagged variable. Sales reflect rule changes after they have occurred.

I then ran the two variations of Reactive Irregular heuristics against the Proactive Irregular heuristic and present the results in Table 5.3. I ran the condition where both competence enhancing and competence destroying rule changes are roughly in balance, because this is the condition under which the Proactive Irregular heuristic is known to

[22] The idea was to simulate a year to year planning cycle whereby decisions are made in response to prior performance. The results were consistent using shorter cycles (e.g., three and six simulated months).

perform better than the Regular and Cyclical heuristics. However, the results are similar in other conditions too.

As can be seen in Table 5.3, the Proactive Irregular heuristic outperformed both variations of the Reactive Irregular heuristics. The mean sales of the Proactive Irregular heuristic were consistently twice that of the Reactive Irregular heuristics, providing support for my hypothesis that Proactive Irregular heuristics are more effective than Reactive Irregular heuristics. Both reactive heuristics performed nearly equally poorly.

In Figure 5.4, I present two variations of the Reactive Cyclical heuristic: (a) *increases* exploration to the 100% in response to *increases* in sales performance from one period to the next and *decreases* exploration to the 0% in response to *decreases* in sales performance; (b) *decreases* exploration to the 0% in response to *increases* in sales performance from one period to the next and *increases* exploration to the 100% in response to *decreases* in sales performance.

FIGURE 5.4

Reactive Cyclical Heuristics

(a)	(b)
When sales performance increases from one period to the next, increase exploration to 100%; When sales performance decreases, decrease exploration to 0%.	When sales performance increases from one period to the next, decrease exploration to 0%; When sales performance decreases, increase exploration to 100%.

TABLE 5.4

Proactive Versus Reactive Cyclical Heuristics Performance (Sales)

(a)				(b)			
Proactive		**Reactive**		**Proactive**		**Reactive**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
1830.5	252.0	388.0	78.5	1661.2	218.2	765.9	109.7
T-Test		**Winner**		**T-Test**		**Winner**	
0.000		Practive		0.000		Proactive	

I then ran the two variations of the Reactive Cyclical heuristic against the Proactive Cyclical heuristic and present the results in Table 5.4. I again present the results in the condition where competence-destroying rule changes dominate, because this is the conditions under which the Cyclical heuristic is known to perform best. However, the results are similar in other conditions, too.

As can be seen in Table 5.4, the Proactive Cyclical heuristic outperformed the two variations of the Reactive Cyclical heuristic. The mean sales of the Proactive Cyclical heuristic were consistently more than twice that of the Reactive Cyclical heuristics, providing support for the hypothesis that Proactive Cyclical heuristics are more effective than Reactive Cyclical heuristics. Reactive Cyclical heuristic (b) performed nearly twice as well as Reactive Cyclical heuristic (a).

Hypothesis 6

Hypothesis 6 was developed as a result of the insights from the qualitative study, which suggested that a firm's level of product diversification was a key variable determining its need to change its balance of exploration and exploitation or stay regular. I reasoned that the effectiveness of the Regular heuristic would improve as the potency of rule changes decreased. I also demonstrated that as the level of a firm's product diversification increases, the potency of its environmental rule changes decreases. If I view product diversification as a

strategy that brings diversity to the firm's environment, then it follows that rule changes need to be larger to undermine the firm's competences in a broader set of businesses. I operationalized product diversification by altering the number of knowledge dimensions upon which the firms compete.

The results revealed that, all other things being equal, the Regular heuristic's performance improved as I increased the number of dimensions used by the firms in the simulation. I presented two experiments increasing the level of product diversification from low (5 dimensions) to high (100 dimensions). I used the condition where competence enhancing and competence-destroying rule changes are roughly in balance, and where the Irregular heuristic is known to perform better than the Regular and Cyclical heuristics.[23]

The results presented in Table 5.5a indicate that firms with low levels of product diversification (low number of dimensions) perform better with the Irregular heuristic than with the Regular and Cyclical heuristics. This is confirmed by the t-test, which indicates that difference between the mean sales of the Irregular heuristic at 1338.2 (S.D. 533.2) was statistically significantly higher than that of the Regular and Cyclical heuristic at 1259.6 (S.D. 522.4) and 1052.2 (S.D. 282.7), respectively.

By contrast, Table 5.5b demonstrates that when product diversification is high (large number of dimensions), the Regular heuristic outperforms both the Irregular and Cyclical heuristics. This is confirmed by the t-test, which indicates that difference between the mean sales of the Regular heuristic at 2055.8 (S.D. 1532.8) was statistically significantly higher than that of the Regular and Cyclical heuristics at 1570.7 (S.D. 952.0) and 23.5 (S.D. 54.6), respectively. This provides support for the hypothesis and suggests that product

[23] I also tested the condition where competence-destroying rule changes dominate, that is, where the Cyclical heuristic performs best, and the results were consistent. However, the number of dimensions had to be increased to around 500 before the Regular heuristic performed better than the Cyclical heuristic. Not surprisingly, the Regular heuristic also wins with high levels of product diversification under the condition where competence enhancing rule changes dominate.

diversification may serve as a useful buffer against rule change, reducing the need to vector the organization (Burgelman, 2002).

TABLE 5.5

Heuristic Sales Performance by Level of Exploration Varying Product Diversification

Low Product Diversification (a)					
Regular		**Irregular**		**Cyclical**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
1259.6	522.4	1338.2	533.2	1052.2	287.7
Comparisons		**T-Test**		**Winner**	
Regular vs. Irregular		0.010		Irregular	
Regular vs. Cyclical		0.000		Regular	
Irregular vs. Cyclical		0.000		Irregular	
High Product Diversification (b)					
Regular		**Irregular**		**Cyclical**	
Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
2055.8	1532.8	1570.7	952.0	23.5	54.6
Comparisons		**T-Test**		**Winner**	
Regular vs. Irregular		0.000		Regular	
Regular vs. Cyclical		0.000		Regular	
Irregular vs. Cyclical		0.000		Irregular	

too dramatically. The impact of gains and losses due to competence enhancing and competence-destroying changes can be spread out within the firm, buffering its losses and tempering its gains, as expected. I reason that this effect can be explained by the decrease in rule change potency created by product diversification.

Boundary Conditions and Robustness Checks

This section outlines boundary conditions for the results presented. It also recounts several robustness checks that were constructed to ensure that the results held up despite minor changes to other parameters or condition. I designed the tests such that failure would

draw questions to the simulation's design and to its theoretical underpinnings, whereas success would indicate support for its overall design, theory, and hypotheses.

Optimal Balance

I thought of and found a boundary condition under which the Regular heuristic outperforms the Irregular heuristic all the time. I fixed the Regular heuristic's exploration to the "optimal level" as suggested by the curves (e.g., Figure 5.1), and gave the Irregular firms a minimum and a maximum of 50% lower and 50% higher, respectively. For instance, if the optimal level for the Regular heuristic is 50% exploration, the minimum and maximum of the Irregular heuristics would be 25% and 75%, respectively. However, in reality, it may be difficult for firms to know when they have reached the optimal level. The Irregular heuristic may be a means to figure out the optimal level of exploration for a firm, which may be a moving target, especially when environments change from being dominated by competence enhancing rule change to being dominated by competence-destroying rule change, or vice versa.

Imitation and Appropriation

I added imitation to the simulation to stress the design assumptions and see how it would affect the results. March (2006) equated exploration with foolishness because of the overwhelming odds against its success. Levinthal and March (1993) likened exploration to public service because even when it does succeed, its benefits often diffuse to competitors whereas its costs remain private to the exploring firm. I ran several experiments adjusting the level of imitation between runs. I operationalized imitation as the ability of a firm to copy the knowledge of other firms. A zero-ability would indicate no imitation, whereas a 100% ability would indicate perfect imitation.

I conclude from these experiments that the heuristics may be highly sensitive to imitation, making it a potentially critical boundary condition or moderator. When imitation is high, it tips the balance in favour of exploitation, as exploration benefits the explorer to exactly the same degree as it benefits other firms.

Switching Costs and Delays

Kogut and Zander (1992) attribute exploitation's inertial tendency to the high switching costs involved in changing an organization's core capabilities. Thus, I reasoned that the Irregular and Cyclical heuristics may incur switching costs beyond those of the Regular heuristic. Shifting firm resources from one project to another carries expenses, such as those related to retraining human resources, retooling, and moving equipment within or between facilities. I modelled this cost as a percentage of previous period's sales[24] for increasing/decreasing exploration/exploitation.[25]

As expected, the tests suggest that switching costs undermine the performance of the Irregular and Cyclical heuristics, favouring the Regular heuristic, especially as switching becomes more frequent and more expensive. Similarly, when the Irregular and Cyclical heuristics were subjected to time delays, their performance degraded. As time delays were increased, the Irregular and Cyclical heuristics effectively become random, because the relationship between the heuristic's execution and the rule change it is responding to becomes Weaker. Thus, switching costs and delays are important boundary conditions for the Irregular and Cyclical heuristics.

[24]We used 365 iterations to emulate a year, but the results were similar when we used shorter periods, such as 30 iterations, or 90 iterations.
[25]For the Irregular heuristic, we balanced costs so that the cost of going up the whole range is the same as going down the whole range.

Inverse and Random Switch Heuristics

As a robustness check to ensure that the Irregular heuristic's performance is due to the timing of its switching and not simply random, I ran the Irregular heuristic against its mirror image and against a Random Switch heuristic. The Inverse heuristic increases exploration in response to endogenous rule change and increases exploitation in response to the exogenous (independent) change, exactly the opposite behavior of the Irregular heuristic developed by Burgelman and Grove (2007). The Random Switch heuristic switches to a random level of exploration in response to both types of rule change (Wilson, 1996). The results for the balanced condition where competence enhancing and competence-destroying rule changes are both moderate, and where the Irregular heuristic performs best, are presented in Table 5.6.

TABLE 5.6

Robustness Check for the Irregular Heuristic

Irregular vs. Inverse Heuristic (a)			
Irregular		**Inverse**	
Mean	**S.D.**	**Mean**	**S.D.**
1580.2	600.0	668.6	454.7
T-Test		**Winner**	
0.000		Irregular	
Irregular vs. Random Switch Heuristic (b)			
Irregular		**Random Switch**	
Mean	**S.D.**	**Mean**	**S.D.**
1283.4	442.6	1124.2	269.9
T-Test		**Winner**	
0.000		Irregular	

The results in Table 5.6a confirm that the Irregular heuristic is superior to the Inverse heuristic. The mean sales performance of the Irregular heuristic (mean = 1508.2, S.D. = 600.0) is more than double that of the Inverse heuristic (mean = 668.6, S.D. = 454.7). The

difference between the means was confirmed by a t-test. The results in Table 5.6b confirm that the Irregular heuristic is superior to the Random Switch heuristic. The t-test confirmed that the mean sales of the Irregular heuristic of 1283.4 (S.D. 442.6) was statistically significantly higher than that of the Random Switch heuristic at 1124.2 (S.D. 269.9). I also found the results to be the same for other environmental conditions (i.e., where competence enhancing rule changes dominate and where competence-destroying rule changes dominate), suggesting robustness. The results also held for the Cyclical heuristic, that is, it too performed better than its Inverse and Random Switch counterparts.

These tests confirm that the performance of the Irregular and Cyclical heuristics is not simply due to changing in their levels of exploration, but can be attributed to the timing of the changes. However, it is interesting to note that the random heuristic did better than I expected. This is possibly because, as the Random Switch heuristic switches randomly upon rule change, it is likely to make the right move at least half the time. Conversely, back in reality, making the wrong move half the time may lead to a quick bankruptcy or an acquisition during distress. Besides, the results are relative to runs such that small differences relative to other runs can make large differences in the allocation of resources among firms. For instance, a firm that increases its exploration after they have made a significant competence enhancing discovery may fail to capitalize on the opportunity by under-investing in exploitation (Levinthal and March, 1993; March, 1991). Moreover, a firm that decreases its exploration after competitors introduce a major competence-destroying innovation may be seen by other firms as reactive, inertial, and may become a ripe target for acquisition and reorganization.

Qualitative Study Results

This section presents the results of a qualitative study of a successful longstanding organization I will call "ABC Inc." I sought to document the firm's exploration and exploitation balancing approach over its lifespan. A spreadsheet containing a listing of all of the company's strategic initiatives was developed and used as a reference guide during interviews. This is analogous to inductively deriving themes in order to make within-theme and between-theme comparisons (e.g., Eisenhardt, 1989). Table 5.7 provides the complete list generated from the ABC Inc. over its 64-year history.[26] Rather than enumerate each strategic initiative chronologically, as if strategic initiatives were non-overlapping, I link them together into a narrative that illuminates the key moves the organization made over its lifespan, using the strategic initiatives as evidence of investment.

TABLE 5.7

64 Years of Exploration and Exploitation

Year	Exploration	Exploitation
1946	Sales agency purchase, Engineering consulting	
1947		Three new subcomponent lines
1948		
1949		New sales office
1950	Territorial expansion (west)	
1951		
1952		Territorial expansion (west)
1953		Territorial expansion (west)
1954		
1955		
1956		
1957		Territorial expansion (west)
1958		
1959		
1960		New office, First warehouse, Extra space to lease

[26] To keep the identity of the firm anonymous, names of places, technologies, firms, and individuals were not disclosed and made generic.

1961	Manufacturing and Sales license, First factory (central)	New sales license
1962	Territorial expansion (east)	
1963		
1964		Territorial expansion (east)
1965		
1966	First regional factory (east), New sales license	Territorial expansion (east)
1967	Related contract work	
1968		
1969		
1970	Laboratory (east), Related manufacturing venture, Self-hauling	New factory (east)
1971		
1972	Backward integration	
1973	Related diversification	
1974		
1975	Backward integration, Related manufacturing venture, Computerization	
1976	Related contract work	
1977	Product diversification	
1978	Product diversification	Line Extension
1979		
1980	Differentiated product line, First major research and development initiative	
1981		
1982	Territorial expansion (far east), Process improvement	
1983	Diversification	Computerization
1984	Diversification	Territorial expansion (east)
1985		
1986	Forward integration, New factory (far east), Market diversification, Forward integration, Backward integration	Territorial expansion (east), Second Laboratory (far east), New warehouse (east)
1987	Territorial expansion (south)	New warehouse (central)
1988	Backward integration	Product diversification
1989	New factory (south)	Computerization
1990		Process Improvement
1991		
1992	Forward integration	
1993	Forward integration (new catalog)	
1994	Backward integration	
1995	New factory (south)	
1996	Process improvement, Digital catalogue, Technical centre	New catalog
1997	Process improvement	Process Improvement, Computerization

1998	Related product development, Forward integration	
1999	Backward integration	Process Improvement, Computerization, New catalog
2000	Forward integration, Backward integration	
2001	Related product development	Factory expansion (west)
2002	Related product development, New U.S. plant	New catalog
2003	Related product development	Technical center upgrade (south)
2004	Related product development	Process improvement, new technical center (south), Related product development
2005	Related product development, Two exploratory acquisitions	Process improvement
2006	Related diversification by acquisition, Backward integration	Major new release of customer facing software
2007	Backward integration, Unrelated diversification, Territorial expansion (international)	New factory (south), New catalog
2008	Related product development	New building for future factory (central)
2009	Territorial expansion (international), Related product development, Forward integration	Process improvement
2010	Forward integration	New catalog, process improvement

Given that this is an emerging area of research, few managers are likely to have explicit knowledge of approaches and heuristics for balancing exploration and exploitation. Rather, they may have tacit knowledge of the heuristics that may be expressed in response to probing questions, which may then allow conversion to explicit theory elaboration and testing (Nonaka, 1994). This observation was confirmed by executives, who had an implicit understanding of the need to diversify their products and markets in time to weather economic hard times. However, they did not readily connect their current balance between exploration and exploitation to future revenue streams. Informants had differing opinions about several of the firm's strategic initiatives, past and present, and did not agree on some of the classifications. Some also regarded the task of differentiating between exploration and exploitation on the basis of the level of newness involved for the firm as irrelevant to their strategy. However, when prompted, they largely agreed about which initiatives were exploratory if they involved new markets, new products, or new competencies. Therefore, while there was general agreement about which initiatives were strategic and whether they

were more exploratory or exploitative overall, the concept of balancing exploration and exploitation to create a steady (and growing) stream of future returns was largely tacit for managers.

What follows is an interpretation of strategically important moves during the firm's history, inferred through consulting multiple sources (e.g., interviews, documents, and observation). I invite other interpretations of the case (Eisenhardt, 1989), but I constructed the narrative to elucidate facts that appear to account for the firm's long-term pattern of growth and improvement, namely, the strategic initiatives of the firm. Splitting them into exploration and exploitation helps to uncover the pattern of firm activities over time and ascertain whether they will affect top line or bottom line growth.

ABC Inc. is a private company and leads its industry in North America in market share and continues to grow its share every year, during market ups and downs. Executives consider market share to be the single best measure of success. It may be useful to frame the case as a story of growth and transformation, not just for the firm, but for the entire industry (Lewin, et al., 1999). I use the term Pi-controlled rule change just as Burgelman and Grove (2007) did, meaning a rule change that puts the focal firm ABC Inc. at a competitive advantage vis-à-vis its competitors. Pi-independent rule change refers to rule changes in the external environment, whether they are brought about by competitors or by distant forces outside the firm's immediate task environment.

The sample includes all of the strategic initiatives that the firm spent material resources on, or which required inordinate time and attention from management. I will also point out the moves by other organizations that served as Pi-independent competence-destroying rule changes for ABC Inc. I divided the company's history into three broad periods depending on the ambidexterity approach and related heuristics it used. The firm moved from a pattern reminiscent of the Cyclical ambidexterity in the early years (1946-

1972), to Irregular ambidexterity in the middle years (1973-1995), to Regular ambidexterity in the later years (1996-2010).

Cyclical Ambidexterity (1946-1972)

Upon returning from World War II, the founder acquired a small sales agency distributing a line of commodity components to professional customers in central Canada. The business proved difficult as competition was price-based with little differentiation among firms and there was too little local business to support a one-line shop. The fledgling firm's inadequate sales prompted experimentation with the provision of consulting services to bring additional revenues. However, this experiment was soon abandoned due to incompatibilities with the sales business. The firm's resources shifted back to exploiting component sales with the addition of three sub-components lines that customers bought together as complementary products.

Aided by the post-war investment boom, the business became viable enough to fund new office spaces and to embark on a program of geographic expansion, culminating in a sales network spanning all Western Canada. As the boom waned, ABC Inc. consolidated its position by adding a warehouse to improve service and a new head office with extra space for future growth, which it leased to a local manufacturer. This territorial expansion made ABC Inc. a regional player and a new contender for national distribution contracts.

In 1961, ABC Inc. decided not to renew its original distribution licence and signed on instead for a national licence with the market leading manufacturer (XYZ Inc.). The license allowed the firm to vertically integrate into manufacturing, gaining control over cost, quality, and delivery. This move changed the game for other sales agencies, as it was the first vertically integrated firm in its market, allowing it to supply custom applications beyond the scope and ability of disintegrated firms. Coupling sales and manufacturing together tightly

constituted Pi-controlled rule change for competitors, later including XYZ Inc., which lacked depth in customization capabilities and relied on cost-based competition instead of providing high levels of customer service.

Having gained exclusive rights to a premier line, ABC Inc. dominated its competitors in the Canadian national market. This period of Pi-controlled change required a new manufacturing facility, expensive equipment and a labour force. The sales organization quickly expanded east adding three new sales offices. Success at manufacturing was quickly consolidated with incremental additions to the main factory and by adding second plant in Eastern Canada to meet growing demand. The firm also acquired another set of complementary manufacturing and distribution licences, further expanding its product offering.

In 1967, the firm explored an opportunity in construction contracting. However, the business was not dependable from year-to-year, and was soon abandoned. Returning emphasis to the components business in 1970, the company expanded its manufacturing capacity in the east, building a new plant to replace its aging factory. This coincided with an exploratory investment in a laboratory to facilitate technical sales with product mock-ups for customers. This move later allowed ABC Inc. to test designs prior to installing them, increasing product reliability. The laboratory also allowed ABC Inc. to modify some commodity products and eventually develop products of its own. It also served as a marketing too demonstrating the organization's technological sophistication.

Around the same time, ABC Inc. ventured into two more related manufacturing businesses, an organic initiative (related products made from unrelated materials) soon abandoned due to technical difficulties and lack of access to distribution networks. They also entered a joint venture with a much larger company to manufacture a major input to the production of most of its products. The firm also invested in a new plant in Western Canada,

which thrived on high efficiency, especially after the firm lobbied for tariff protection from foreign dumping. Product diversification was not unique in the industry, whereas such backward vertical integration had been. This move put ABC Inc. at par with diversified competitors that could also use funds from other businesses as bail during times of poor performance.

The overall pattern of investment during the first 26 years of the firm resembles Cyclical ambidexterity, because the firm often did not have the resources to do both exploration and exploitation at the same time. For instance, there were six gaps of three or more years between exploratory investments and between exploitative investments, each of which probably did not last more than one or two years (see Table 5.7). These gaps indicate that the ABC Inc. was not investing substantive resources in both activities at the same time, but oscillated emphasis between exploration and exploitation sequentially. Shifts in the early years may have corresponded to strength and weakness in market demand and cash flow. Over this period, the firm grew from a handful of employees to around three hundred.

Irregular Ambidexterity (1973-1995)

In 1973, ABC Inc. acquired a licence to manufacture an upmarket component and began manufacturing its own innovative version of a product they previously sold under licence. In 1975, the company built a data centre, including leading edge manufacturing and accounting systems, all in-house. Order entry systems for mass-customizers were not available at the time from vendors such as IBM. Computerization was considered critical to the firm's ability to provide on-time delivery, a key determinant of customer specification for commodity products. A key design element of the company's computer system was developed by a mathematician who later became the CEO and main owner of the organization. ABC Inc.'s software development capability later became an important part of

its marketing strategy, and eventually constituted Pi-controlled rule change, as no other direct competitor could match its software's sophistication. Internal software linked into customer facing software allowed for tighter coupling between customer needs, and firm resources and competencies.

In 1976, ABC Inc. explored two joint ventures in construction contracting in Eastern and Western Canada. Although profitable at first, subsequent jobs were marginal and the ventures were wound down within two years. Meanwhile, the firm acquired four additional licences to manufacture and sell a set of related products. This move was consolidated with the establishment of a new focused division. The firm expanded its production facilities and began to manufacture more sophisticated versions of their existing products, designed for environments with stringent requirements. Although another competitor was slightly ahead in the development of these products, ABC Inc. was a fast-follower and helped to co-create a rule change for many other firms that had not capitalized on the potential to recombine components into higher margin applications.

Around the same time, ABC Inc. acquired a license to sell their core products into regions of Asia and established a manufacturing joint venture with a local partner to sell and manufacture there. ABC Inc. could not establish itself in the new region because it was unable to compete on small projects where lower cost products were preferred. While successful at winning the larger prestige jobs, the firm was unable to weather the business cycle without the smaller jobs to round out the bumps. It could not win the small jobs because their products were over-engineered for the lower standards of developing nations. It tried to correct this by diversifying into third party manufacturing, but they could not compete at cost despite employing expensive flexible machines. The firm later decided to use its resources differently and exited the Asian market.

In 1983, toward the end of another recession, the company computerized its order entry and pricing processes. This was a significant step, allowing it to capitalize on previous investments in automation, and getting another step further to the fully automated electronic relationship the firm maintains with its customers. This particular improvement to the computer system reduced the need for order entry resources, providing a significant opportunity for cost reduction. The customer-facing software allowed customers to create complex ordering instructions that where automatically translated into production orders and instructions. This further increased ABC Inc's delivery speed and allowed it to handle an increasing array of customized variations.

A key decision in 1986 to not renew their core sales licence with XYZ Inc. started a new era of Pi-controlled rule change for ABC Inc. The age and lack of patents on most of the products they were manufacturing for XYZ Inc. made it possible for the firm to continue producing them under their own brand, giving them more control over pricing. ABC Inc.'s entire engineering department was put to work doing product development to fill in remaining gaps in their product lines. They invested in new computer-based drafting system to aid with this. By 1987, they had developed their first independent product line. More importantly, ABC Inc.'s historical restriction to the Canadian market ended with the XYZ Inc. license, allowing the firm to enter the larger U.S. market. They adopted the predominant non-exclusive "rep model", employing independent sales representatives. This allowed ABC Inc. to expand into the established U.S. market much more quickly than it had in Canada by owning non-exclusive sales agencies. Over time, this move constituted Pi-controlled rule change that was destructive to XYZ Inc. and its other direct competitors in North America, which now had a formidable competitor out of Canada with the ability to bid head-to-head with it in this key market. In 1989, ABC Inc. added the first of three high-volume manufacturing plants in the U.S., consolidating its control over transportation and labour

costs. As a private company dedicated to investment and growth, ABC Inc. quickly started taking market share from their rivals, which were mostly divisions of publicly-traded multinational conglomerates.

The overall pattern of investment during these 22 years can be described as Irregular ambidexterity. The firm alternated emphasis sequentially between exploration and exploitation, but continued to invest resources in both activities, never eliminating either of them completely. By the end of this period, the firm's employee count had doubled to around 600. It had the highest market share in Canada, and was a quickly growing share in the U.S., yet was still a marginal player in this larger market.

Regular Ambidexterity (1996-2010)

After a couple of false starts in the late nineties, ABC Inc. switched from batch and queue to flow manufacturing. This moved increased the efficiency of its commodity factories, allowing it to cope with increased price pressure. ABC Inc. employed dual structures (Duncan, 1976), dedicating its U.S. factories to high-volume products and tailored its main plant in Central Canada for high levels of customization and to accommodate new and innovative products. Flow manufacturing also improved customer responsiveness by allowing the firm to make on-time deliveries even during peak periods.

In the early `90s, ABC Inc. decided that it needed to educate its sales representatives and their customers about the virtues of higher performing and higher margin products. Their investments in laboratories allowed them to publish accurate long-term performance data to make the case for higher upfront costs. ABC Inc. developed technical centres and training software to deliver focused education. This move into customer education is unique to the industry and constitutes Pi-controlled rule change in the long run. The investment required to educate the industry remains unmatched by ABC Inc.'s competitors. The shorter time horizon

of ABC Inc.'s publicly traded competitors may have prevented them from entering this game. In 2010, ABC Inc. developed the industry's first textbook of applied science, which it will provide to universities, catching future industry stakeholders while they are young.

New green-building standards in the late `90s constituted Pi-independent rule change. ABC Inc. responded by exploring product development of several niche lines to round out its portfolio with energy efficient products. These included several lines of energy efficient models that required more flexible machinery and better painting capabilities. The different technologies involved in these products also required large investments in laboratories to test and certify product performance capabilities.

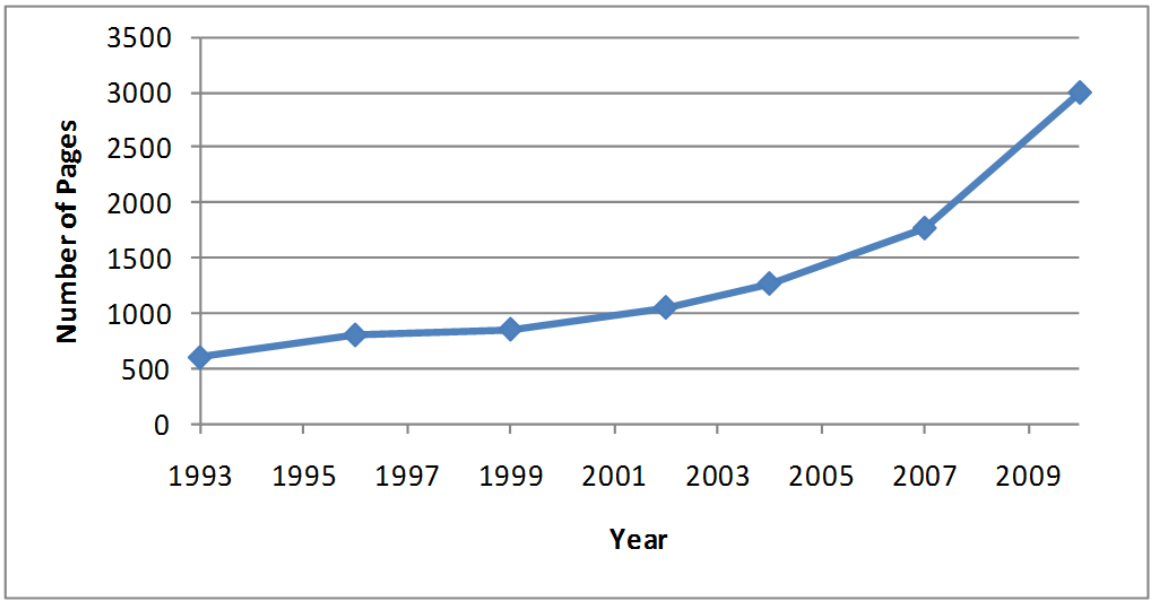
In 2000, the company built and launched an Internet-based software system to create a comprehensive electronic relationship with U.S. sales representative network, reducing face-to-face contact to informal meetings, application engineering, and consultations to improve sales. Combined with efficient manufacturing to enable on-time delivery, the high level of customer service provided by the firm constitutes Pi-controlled rule change. They soon combined software tools into an integrated suite and began to supply parts of the software to its sales representatives' customers, aiding in the education of the field's key stakeholders.

In the early 2000's, ABC Inc. built another factory in a lower labour cost region of the U.S. allowing them to plan to "infinite capacity", meanwhile, they made several small acquisitions in order to secure new technologies for different product markets. Some of these investments floundered because of difficulties entering established distribution networks. Others allowed them to become increasingly creative in product development, increasing the technological sophistication of its products, and contributing to Pi-controlled rule change in product development in current years.

ABC Inc.'s explosive growth in product development during the last 20 years is demonstrated by the number of pages in its catalogue, growing from about 600 pages in 1993 to over 3000 pages in 2010 (see Figure 5.5). The growth rate of the product catalogue is exponential. However, the recombination of technologies enabled by ABC Inc.'s investment in laboratories has allowed it to create increasingly innovative products. For instance, they have recently combined three previously disconnected commodities into a higher performing integrated combination product that is unique in the industry. ABC Inc.'s technological leadership constitutes Pi-controlled rule change as most of its competitors lack the laboratories needed to develop more complex integrated products.

FIGURE 5.5

Sixteen Years of Product Development and Acquisitions



Although the company has focused on the North American market, it has begun exploring international opportunities. It recently signed a licensing arrangement with a large manufacturer in the Middle East to make and sell some of its basic commodity products within the region. International sales remain exploratory; however, ABC Inc. plans to build an international production facility in the coming years. Yet, ABC Inc. has formidable foreign rivals to contend with, some with comparable laboratories oversees. ABC Inc. may yet be susceptible to Pi-independent change prompted by the entry of a global product technology leader to its traditional markets. However, the more advanced ABC Inc. software may prove a sturdy barrier to such entry. If ABC Inc. can diffuse its software globally, then it might climb to global supremacy. However, it might instead decide to practice mutual forbearance with its foreign rivals and expand instead through increased product variety and sophistication, taking on more niches within the needs of its sales representatives and their customers.

The last 14 years of the company's history appears to be increasingly using Regular ambidexterity in exploration and exploitation, as investments were made in both activities in nearly every year. ABC Inc. is now leading in market share both in Canada and the U.S., and has begun to compare itself to much larger global players, targeting them with its strategic intent. It now has over a thousand employees and counting. I must wait for the story to unfold further to find out if it will choose to diversify further and increase the product value of its products, globalize, or shrink.

Theory Elaboration

What did we learn from ABC Inc.'s experience? The pattern left by its heuristics (see Table 5.7) suggest that the firm moved from using Cyclical ambidexterity in the first part, to Irregular ambidexterity in the second part, and Regular ambidexterity in third part of its lifespan. That is, the firm morphed from one heuristic to another over its lifetime, like shifting gears as the organization grows. Although firm size appeared to matter in the early years, making the firm more Cyclical, it was ABC Inc.'s level of product diversification (Chandler, 1962; Rumelt, 1974; Ramanujam and Varadarajan, 2006) that accounts for the evolution of its strategic ambidexterity approaches, and its continued growth. Although the managers often did not think of it in this way, the transformation and the sheer pace of the firm's exploration output is impressive. However, with a new organizational structure directly linked to the central authority of the owner, the hurdles around exploration and exploitation seem to be managed ambidextrously. This was evidenced in the large meetings that took place frequently and richly, not just with internal stakeholders, but with the whole community. Both production and innovation issues were dealt with at the same table and great efforts to make them work together like a machine.

Evolutionary theories assume that organizations undergo qualitative changes as they age and grow (Mintzberg, 1991). The level of product diversification firms undergo as they grow may be a key factor in graduation from one heuristic to another. Being large in only one business makes that business vulnerable to destructive innovations by others, who would provide the same service at a discount by better filling the space between our wants and needs, or better mediating our senses (McLuhan, 1964). The model suggests that environments must also change in order for the heuristics to have been successful in each era of the firm's growth. It is possible that during the company's growth, its environment changed in predictable ways. For instance, during the boom of the early years, the firm exploited geographic expansion. During the recessions, the firm focussed its efforts not on growth but on retention, requiring large investments in research to find the right tools and to engineer solutions.

Beyond the stages of evolution, ABC Inc.'s heuristic rarely entered into long phases of pure exploitation, with the above exception. This suggests that continual exploration is important in good times and even during recessions. It also means that customers need to be pursued even harder in order to be converted. Over the last two decades, ABC Inc.'s competitors seem to have been under-investing in exploration. Whereas ABC Inc. spent the first 50 years catching up to competitors, the last two decades have seen the firm transition into a technological leader, and an era of multi-pronged (Pi) controlled rule change. ABC Inc. applied the same speed it used to catch up with its competitors to surpass them once it had closed the gap; like the army cadet that enters a course with superior knowledge, but falls behind as the other cadets learn to learn faster. ABC Inc.'s success is evidenced by its ability to fund the last decade of its growth chiefly by retaining earnings rather than using debt. This move provided it with the liquidity needed in hard economic times. Their industry is currently suffering as a ripple effect of the financial crisis.

A growth heuristic that follows ABC Inc.'s three-stage approach might be useful knowledge for entrepreneurs and young firms aspiring to climb the spiral. It suggests that even a competitive commodity business can be turned around if the education, expertise, and market dominance are in play.

For instance, the simulation suggested that Cyclical ambidexterity's starting period requires that the firm first expand its scope of operations into a going concern, and that means regionally expanding while keeping centralized control. The Irregular ambidexterity phase has the firm investing more regularly in exploration, but also vectoring from time to time into periods of drought and pure exploitation (Burgelman, 2002). The Regular ambidexterity phase sees the firm continually curtailing exploitation with continuous exploration, although in smaller relative batches. Instead of drawing the whole firm into an innovation, only a portion of the firm is pulled away from developed the next candidate invention.

The gestation period of the firm's exploratory investments also increased over time. For instance, investing in educating the industry is very long-term, as is building laboratories. Whereas in the early part of the firm's history, its exploratory projects succeeded or failed within just a couple of years, the company later focused on longer term initiatives that would take decades to be evaluable. A long-term focus smoothes out the balance of exploration and exploitation activities, for instance, a ten-year project keeps focus on exploration long enough for several two-year initiatives to fail or launch. Strategic initiatives with long-term gestation periods help to regulate a firm's oscillations between exploration and exploitation by creating a layered constant or base level of exploration from year to year, dampening oscillations to extremes of either activity.

I advanced primitives as ideal types, adding a temporal lens and an evolutionary approach to the study of the optimal heuristics for balancing exploration and exploitation

(Ancona et al., 2001; Gupta et al., 2006; Simsek, 2009). The ideal types may seem primitive but they are helpful in elaborating a parsimonious and valid theory. If we view ABC Inc.'s approach as an evolution through the three ideal types over its history, managers might become strategic leaders and may envision transition phases in their own businesses. The company was good in spotting opportunities and had learned to ignore threats to specific parts of its business under the cloak of the larger entity. That ABC Inc. responded to environmental changes much as Intel did (Burgelman and Grove, 2007) suggests a proactive heuristic with fewer autonomous processes and more central guidance by a higher authority. Assignments were handed out to engineers who delivered incremental and radical new technologies and the labs to support their development were also provided.

ABC Inc. tightened its range of exploration and exploitation activities, becoming like the Regular heuristic. This may partially reflect the firm's product diversification. Diversification of products reduces the need for comprehensive revolutions at the product level (Hamel, 1989). This insight is developed further in Hypothesis 6 in the Model and Hypothesis chapter.

We may develop new hybrid types with the knowledge of these stages. For instance, different sequential combinations of the ideal type heuristics could lead to new high performing combinations under varying environmental conditions. For instance, when environments change from dominating enhancement to dominating destruction, then it should adjust to become less regular in its approach. Destructive rule change undermines competences in current products, making vectoring into new ones quickly more important (Burgelman, 2002). In such environments, opportunities must be exploited quickly enough to get benefits before they disappear. For instance, latent innovations that may have fit between two generations of a technology may be made obsolete by the introduction of its replacements. Consider the number of potent variations between floppy disks and flash

drives. Conversely, if an environment goes from malevolent to benevolent, that is, competence enhancing rule changes become dominant instead of competence-destroying rule changes, then a firm should quickly adopt a more Regular approach to ambidexterity, and vice-versa. Adopting Regular ambidexterity after bouncing around cyclically from business to business means a serious investment in freezing the organization into a fixed split of investment in exploration and exploitation that is monitored and realigned continually over time. Structures serve to preserve ambidexterity (Duncan, 1976), and to prevent premature evacuation of the business after the first sign of a problem with the business model.

To reconcile the relationship between product diversification level, environmental conditions, and vectoring (Burgelman, 2002), we must view them as working in concert. Product diversification tends to smooth out the environment by entering more distant niches. This would seem to automatically create an environment where competence enhancing changes become as potent as their mirror image of competence destructive rule changes (i.e., for other firms). In other words, product diversification is a way to tip the environmental ratio toward creation over destruction for the firm (Schumpeter, 1939), effectively selecting its own environment through adaptations. As most diversified firms enter unique sets of businesses (Rumelt, 1994), each diversified firm has a unique overall type of rule change environment (competence enhancing, competence-destroying, or balanced).

However, the old issue of selecting an industry remains problematic (Porter, 1980). The qualitative study reveals that ABC Inc. used vertical integration as a long-term exploration initiative. Once the competence was developed to bring the resource in-house, it is then leveraged for product diversification. Thus, a sales agency morphed into a manufacturer and then into a technology leader. This pattern is likely repeatable in other industries, but it requires a specific view of vertical integration as exploratory projects and not simply as a means of exploitation. The ability to recombine competencies to develop new

integrated products and services attests to the effectiveness of ABC Inc.'s pattern of development, and suggests that this view of innovation could help other firms, too.

Results Related to the Hypotheses

As I have previously explained, Hypothesis 6 was fully inspired by the qualitative research conducted at ABC Inc. In this section, I will examine how the data gathered from this field study also lends support to Hypotheses 2a and 4a. According to Hypothesis 2a, Regular ambidexterity will be most effective in environments that are dominated by competence enhancing rule change. Hypothesis 4a predicts that the relationship in Hypothesis 2a would be stronger under conditions of high competitive intensity.

ABC Inc. evolved over time from using Cyclical ambidexterity, to an Irregular approach to ambidexterity, and then to a Regular approach. When its scope of operations was largely limited to the protected Canadian market, competitive intensity was not as high as it is today due to the North American Free Trade Agreement and increased competition form low cost foreign exporters. Before investing in new product development capabilities in the 1990s, the firm's manufacturing competence was core to its strategy. Earlier its core competence was in sales only. It retained all three faculties and continues to invest in all of them simultaneously. The tension between exploration and exploitation that is endemic to firms was also evident in fierce debates and conflict resolution among actors with otherwise potentially diverging interests.

During the most recent period of the company's history, ABC Inc.'s environment was characterized by competence enhancing rule change. This was evident in the CEO's statements regarding unlimited opportunity for new product and business development, and the lack of need to eliminate products from the company's catalogue, despite a significant temporarily drop in market opportunity. The interviewees could point out dozens of potential

new areas for the firm to evolve its business, including related diversification, more sophisticated and integrated products, and global expansion. This was largely due to the product development capability ABC Inc. developed since the late 1990s. The same people could only identify a very small number of cases (around ten out of hundreds of different products) where products had to be removed from their offering due to obsolescence or lack of demand. This is partially due to the high inertia present in their institutionalized industry. ABC Inc. had to be careful not to over-extend itself by exploring too many new opportunities at a time (Levinthal and March, 1992; March, 1991). The lack of threat to its core business reduces the need for drastic switching to more exploration and its liquidity ensures it can survive recessions through vectoring or alignment (Burgelman, 2002). A Regular approach to ambidexterity may have contributed to the firm's increased performance in recent years; supporting Hypothesis 2a.

During the latter period of the firm's history, competitive intensity was also very high. This was evidenced by aggressive pricing tactics employed by its competitors, especially to win high-prestige projects. It was not uncommon for ABC Inc. to take a very small margin or no margin at all in order to remain competitive on such projects. The competitive bidding process that characterises the sales process in ABC Inc.'s industry ensures that customers are aware of nearly all of its competitors' product price/performance attributes, and does not allow firms to hide weaknesses (Day, Shocker, and Srivastava, 1979). That the firm used Regular ambidexterity during this period provides preliminary support for Hypothesis 4a's validity.

CHAPTER VI: DISCUSSION

This thesis contributes to the field in three main ways. First, uncovering and explaining heuristics that explain resource management decisions related to exploration and exploitation, and the factors inside the firm and in the business environment that influence these, i.e., strategic ambidexterity. While some of these heuristics have individually received prior attention in the literature (Burgelman and Grove, 2007; Lovas and Ghoshal, 2000; Brunner et al., 2006), bringing them together into a coherent framework composes a contribution.

Second, I developed a simulation model that improves on the state of the art of the domain by decreasing the granularity at which the universe is modeled. Rather than single firms with random environments, I extended the modeling to groups of firms. Although not entirely unique to the strategic literature on exploration and exploitation (Lee and Ryu, 2002), modeling firms' internal dynamics as probabilities and the agents as firms competing for customers is largely new to the field. This brings the domain of organizational management the viewpoint that has been advocated by the field of multi-agent systems; that complex systems have to be studied both from an individual and environmental point of view (Anderson, 1999).

Thirdly, I have supplemented simulation results with an extensive case study on the changing practices in strategic ambidexterity, which have been used by a successful business organization over sixty-four years. Longevity was important for this study because a firm's temporal ambidexterity pattern cannot be known with measuring activities from the distant past; since the idea is to observe the pattern of exploration and exploitation of firms over time. The temporal imprint of ambidexterity and emphasis can be detecting by examining the lulls and bumps in exploration and exploitation activities.

The remainder of this chapter reviews and integrates the major findings of the simulation and qualitative study with related literature. It also links the findings to other theories of strategic ambidexterity, and attempts to provide some nuggets of advice for practice and an agenda for future research. Strategic ambidexterity is a nascent subfield in strategic management theory on exploration and exploitation (Raisch and Birkinshaw, 2008). This thesis elaborated temporal strategies for balancing exploration and exploration over time. It is new to this stream to focus on the timing heuristics used by firms to enable organizational ambidexterity (Duncan, 1976; Gibson and Birkinshaw, 2004). Much more attention has been given to examining structural and behavioral approaches to implementing ambidexterity, focusing on the internal environments of organizations and their network structures (Chen and Katila, 2008; March, 1991). Strategic ambidexterity turns the focus to the dialectic between the internal and external environments over time, and the contingent effects of rule changes on performance and survival (Burgelman and Grove, 2007).

Reasoning based on the mechanisms of evolution guided by strategic intent (Hamel and Prahalad, 1990; Lovas and Ghoshal, 2000) suggests an ambitious role for strategic leaders; likening strategic leadership as guide of balanced internal and external ecological processes (March, 1991) in the pursuit of longevity and performance (Burgelman and Grove, 2007; March, 1991).

Summary of Key Findings

Firms may need to reign in their exploration when the industry environment is dominated by competence enhancing rule changes to avoid being flooded by new information and floundering in its complexities (Cyert and March, 1963). The Regular approach to ambidexterity was the most successful under these conditions in the simulation as well as at

ABC Inc. This suggests that maintaining a steady mix of exploration and exploitation over time may be the best strategy in environments where opportunities eclipse threats.

By contrast, competence-destroying rule changes require firms to replace existing businesses, and to discover enough new opportunities for its current competences to keep drawing income even as some products become obsolete. When environments are dominated by competence-destroying changes, firms may need to increase their exploration, but only temporarily. Under high competitive intensity, a firm needs to dedicate the entire weight of its resources to an innovation stemming from exploration in order to stay ahead of competitors' advances in imitated technology. The Cyclical approach was most successful under these conditions, suggesting that switching between exploration and exploitation dramatically may be the best way to increase performance in them.

Finally, the Irregular approach was most successful in the middle ground, that is, where competence enhancing and competence-destroying rule changes are roughly in balance with each other. This supports Burgelman and Grove's (2007) theory of strategic dynamics at Intel and firms like it. Using an approach that is a hybrid between Regular and Cyclical ambidexterity yields a simultaneous-sequential approach to ambidexterity, thus affording its user the benefits of both extremes with fewer of their problems.

These findings may go a long way toward explaining the conflicting findings between research on sequential and simultaneous modes of ambidexterity (Gupta et al., 2006). Several researchers have argued that simultaneous ambidexterity is more important in highly dynamic environments (Chen and Katila, 2008; Jansen et al. 2005; 2006). Yet, Venkatraman et al. (2007) empirically found that sequential ambidexterity was superior in the software industry, which is normally considered highly dynamic (Nadkarny and Narayanan, 2007). This suggests a problem with current theory and or with current methods of measurement of exploration and exploitation. A better measure of exploration and

exploitation balance can be obtained by sketching out company histories and examining the footprints of their strategic initiatives over time. The pattern revealed can then be compared to those of more and less successful competitors to better understand the causes of their current positioning.

Some measures of environmental dynamism look at changes in sales as an approximation of actual institutional transitions or rule changes (Dess and Beard, 1984). However, sales are based in demand, which is likely to lag rule changes considerably, like the wake of the shocks. Depending on the average incubation period for innovations in a given industry (e.g., around five years at the firm I studied), the lag could be very distorting. Understanding the "rules of the game" and identifying critical moves and firm responses to them may be a better way to learn about strategic ambidexterity (Schultz, 1998, 2003).

While rule changes may open up new opportunity dimensions for firms, they may do so in part by destroying the value of other stakeholders' competencies. Thus, the problem in the literature may be resolved by arguing for "types of environment" rather than dynamism (or turbulence) as a uniform or singular construct (Dess and Beard, 1984). Measures of dynamism that look at the frequency of change in sales or technology without noting amplitude and whether the change was competence enhancing or competence destroying may be missing the key role of types of rule change environments and their potency and urgency for firms.

Competitive intensity moderates the relationship between temporal heuristics for strategic ambidexterity and selected environments. Prior research has suggested that ambidexterity, in general, is more important when competitive intensity is high (Jansen et al., 2005, 2006; Simsek, 2009). Competitive intensity does not change which heuristics are most effective, but, rather, reduces the magnitude of the performance differences between them. In non-competitive environments, dynamic temporal approaches to ambidexterity may not be

worth the cost of switching between exploration and exploitation due to inertial forces and institutionalization (Scott, 2007). By contrast, in highly competitive environments, the differential effectiveness of temporal heuristics for strategic ambidexterity may more than compensate for their switching costs.

Supplementary analyses also suggested that the direction of switching responses matter. Increasing exploration or exploitation randomly or in response to the wrong stimuli or with excessive delays may reduce the performance of Irregular approaches to strategic ambidexterity. Finally, dynamic temporal heuristics may also be more relevant for single business firms than for highly diversified firms. The results demonstrate that as firms increase their level of product diversification, the value of responding to rule changes by dramatic switching between exploration and exploitation lessens. This reflects the fact that fewer types of products require fewer competences and thus each one counts more when they are destroyed by rule changes.

Barriers to imitation are often thought of in terms of intellectual property rights, causal ambiguity, and complexity. All things being equal, higher levels of imitation reduced the optimal level of exploration of firms, and leads to a "race to the bottom" whereby every firm tries to avoid exploration, as if exploration were a public service to be externalized (Levinthal and March, 1993). In such circumstances, sequential modes may put the firm behind rivals in dimensions of importance for short term organizational survival. Imitation barriers reduce the value of temporal heuristics for strategic ambidexterity increases, except when competence enhancing rule change is highly dominant. In short, dynamic heuristics may be particularly vulnerable to imitation.

Robustness checks revealed that the Regular approach is best when the firm can find the optimal level of exploration for the system as a whole. If all the firms are set to the optimal level as determined by previous runs with similar settings, their performance

differences drop because the potential industry earnings are shared among many smaller winners. If it's possible to match the probabilities of an environment perfectly, the value of having done so would decline if imitators could easily learn to copy the winning formula. Chasing the optimal balance may also be akin to shooting at a moving target, and might look irregular if one were to measure its balance over time. This does not mean that a Regular heuristic is impossible; indeed, it may be achievable. However, the optimal balance will likely bounce around, giving the impression of temporal dynamism.

In some contexts, switching between exploration and exploitation is a matter of moving flexible human resources between projects (Lovas and Ghoshal, 2000); whereas in other contexts, investments in fixed assets create switching barriers. In the latter case, dynamic temporal heuristics for strategic ambidexterity may simply be too expensive, especially when rule change becomes more potent. This is consistent with current thinking in the strategic change stream, where switching costs may be due to inertial forces (Sastry, 1997). In short, firms may need to use time-pacing (regular rhythm) in some circumstances, whereas they may benefit from event-pacing (an irregular rhythm) in other environments (e.g., Gersick, 1994; Sastry, 1997).

Hints for Future Research

Beyond the limits of simulation studies I discussed in the Methodology chapter, and the well-known issues related to external validity in qualitative field studies (see Eisenhardt, 1989), I outline some of the limitations of the theoretical arguments of the study and hint at possible avenues for future research.

Possible Organizational Moderators

In keeping with the tradition of creating parsimonious and internally valid simulation models (Davis et al., 2007), I intentionally kept potentially confounding concepts equal, e.g.,

firm size, age, scope, slack, market orientation, price point, and cost structure. In their comprehensive review of the ambidexterity literature, Raisch and Birkinshaw (2008) highlighted some of these variables as moderators in their model. Small firms with low slack, poor endowments, and focused strategies of either stability or variety may use specialized strategies or limited forms of ambidexterity (e.g., Cyclical), whereas large, multi-unit, well-endowed firms with higher slack, and market, as well as entrepreneurial orientation, may intend to become simultaneously ambidextrous organizations (Ebben and Johnson, 2005; Gibson and Birkinshaw, 2004; Jansen et al., 2006; Kyrweakopoulos and Moorman, 2004; Lubatkin et al., 2006; Raisch and Birkinshaw, 2008; Venkatraman et al., 2007). In the future, researchers may incorporate variations in these factors to examine their influences and interactions.

Ambidexterity

Measures of exploration and exploitation have failed to account sufficiently for the pattern of temporal fluctuation endemic to approaches to strategic ambidexterity (Gupta et al., 2006; Simsek, 2009). Understanding these heuristics seems to be a prerequisite to designing instruments to capture them with large sample studies. Studies of additional organizations that list their strategic initiatives and plot them over time may be helpful to further develop this line of inquiry into strategic dynamics.

Strategically shifting resources from exploration to exploitation and vice-versa in response to environmental change, or to the institutional rules of the market or game, does not imply a sine wave of regular switching (Kim and Rhee, 2009; Venkatraman et al., 2007). On the contrary, it presumes a conscious switch from one activity to the other in response to perceptions that material changes have indeed occurred, yielding a potentially irregular or non-linear pattern of change (Burgelman and Grove, 2007). It would be useful to find

evidence for the hypotheses developed herein using archival data, surveys, patents, announcements, and annual reports. However, methods that detect irregularity may need to be developed. These will have to be custom designed to suit the organizational context. For instance, if a large enough data set could be constructed and analyzed, then the theory could be falsified by findings that indicate that rule changes are unimportant or insignificant when other factors are controlled, such as prior performance, initial size, and initial endowments.

Rule Change Recognition, Timing, and Potency

There remains a gap in the study of the nature of rule change, both organizational (Shultz, 2003) and environmental and both combined (Burgelman and Grove, 2007). Research has demonstrated that, on average, executives pay much more attention to threats than opportunities (Barr and Glynn, 2003). Future research may seek to examine the extent of agreement about rule change among industry members (DeSarbo, Grewal, and Wind, 2006; Griprud and Gronhaug, 1985; Porac and Thomas, 1990). Strategic recognition may be developed further as a concept and construct in order to gain an appreciation of the gap between "objective" and "subjective" interpretations of rule change (Burgelman and Grove, 2007; Grove, 1996). Do executives make roughly the same errors when interpreting their environments? Do they have common blind spots that are highly contextualized for the world of trade and industry? Do winners systematical err less in deciding which rule changes should be ignored and which should be acted on now?

The magnitude or potency of a rule change, in terms of the proportion of a firm's competencies it may undermine, is an important aspect of rule change that also deserves further study. If a rule change leads to the obsolescence of 1% of the firm's resources and capabilities, dramatic readjustment may not be required, and a steady pace (regular rhythm) may win the race (D'Aveni, 1999; Gersick, 1994). However, if the rate climbs to 50% or

more, throwing all of the firm's resources into exploration may be required, despite the disruption this creates for an organization (Burgelman, 1991). This is similar to the Burgelman and Grove's (2007) suggestion that the amount by which to increase and decrease exploration/exploitation should be in proportion to the net amount of potential industry earnings the threat or opportunity represents.

All things being equal, product diversification reduces rule change potency and competitive intensity increases rule change potency. Diversification fragments organizations, creating divergence in its knowledge and institutions, as agents move the organization down contradictory paths. When the rules change in one part of the business, a rule change in another part is likely to compensate for it. Competitive intensity works by making it increasingly rewarding for firms to follow technological paths that improve customer value because customers are more able to spot superior products and adopt them. Thus, when the rules change in a competitive environment they have large ramifications for firms, whereas in non-competitive environments, new innovations could be ignored and the products deemed ahead of their time because customers are not interested in learning about the product.

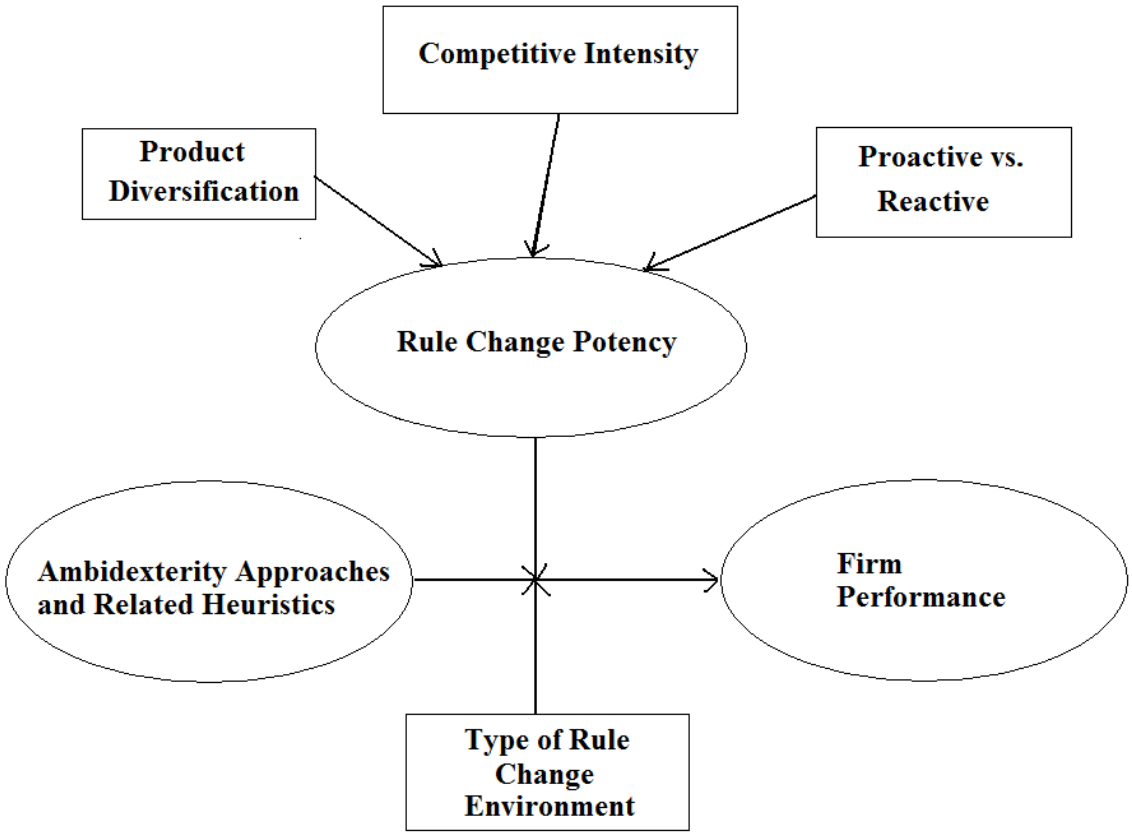
Whether a firm uses a proactive or reactive approach may also have an impact on the rule changes in its environments. If a firm embarks on a rule change before it is clearly needed (proactive), it may find itself overwhelmed by a tacit resistance among those firms that are profiting from the current environmental conditions. The more proactive firms there are, the more likely an industry will encounter runaway industry change and an increase in the overall rate of innovation (Burgelman and Grove, 2007; March, 1991). Success at changing the rules of the game in a fashion the focal firm can control has a higher potential value for it in an environment composed of reactive firms. As the rate of innovation is retarded, the magnitude of each innovation is likely to increase. There may be a small window of opportunity between the time that the first strategist sees the plot, and the time

that all the rest do. The longer the lag between initial recognition and full recognition may at times encapsulate years, decades (e.g., a financial ponzi scheme), or even centuries (unsustainable empires). All else being equal, the more complex the game, the longer the window stays open.

This suggests rule change potency as a latent variable that may moderate the relationship between strategic ambidexterity approaches and firm performance, which could be examined using structural equation modeling or some other statistical approach (see Figure 6.1). I propose that the effectiveness of heuristics for strategic ambidexterity may depend upon the potency of rule change in the environment, and the type of rule change environment, whether it be competence enhancing or competence-destroying. For instance, if a potent Pi-controlled rule change is competence-destroying for the firm, it may want to abandon it early (e.g., Intel's experience with RISC). If a potent Pi-controlled rule change is competence enhancing for the firm, it may want to vector the organization (Burgelman, 2002). If a potent Pi-independent rule change is competence-destroying for the firm, it may want to increase its exploration considerably. If a potent Pi-independent rule change is competence enhancing for the firm, it should follow fast.

FIGURE 6.1

A Tentative Testable Model of the Relationship of the Ambidexterity Approaches and Firm Performance Moderated by Rule Change Potency as a Latent Variable



Timing and Implementation

Given that structure and strategy affect each other (Amburgey and Dacin, 1994; Chandler, 1966), there is an opportunity to examine the match between temporal heuristics for ambidexterity and modes of implementation. Both formulation of strategy and its implementation are equally important, as plans without execution are useless. I examined the first half of the equation, or strategic ambidexterity (Raisch and Birkenshaw, 2008). However, firms may achieve ambidexterity in many ways, e.g., dual structures (Duncan, 1976), flexible internal contexts (Gibson and Birkinshaw, 2004), strategic alliances (Holmqvist, 2004), or with leadership (O'Reilley and Tushman, 2008). Which mode is

implemented may be a matter of organizational politics, institutional environments, or managerial preference (Raisch and Birkinshaw, 2008). However, some modes may be more compatible with different temporal patterns of ambidexterity, be they sequential (Venkatraman et al., 2007), simultaneous (He and Wong, 2004), Cyclical (Simsek, 2009), Irregular (Burgelman and Grove, 2007), or Regular (Brunner et al., 2008). I focused on temporal heuristics for achieving a balance of exploration and exploitation under frictionless conditions, keeping all else equal, but existing structures can influence, restrict, or add costs to the temporal strategy that a firm adopts. Strategic ambidexterity research might expand on the temporal aspects of cooperation, mergers and acquisitions, and firm size asymmetries in the model. Peteraf and Shalley (1997) argued that firms in consolidated industries are more likely to engage in collective behaviors. For instance, incumbents may buy potentially competence-destroying technologies, and store them, or develop them in storage until their value becomes greater than that of the traditional business (Chen and Katila, 2008). Vectoring toward an emerging technology before it matches or exceeds the value of the current business may amount to unsustainable cannibalization (Burgelman, 2002). Similarly, strategic alliances, joint ventures, and acquisitions may allow firms to keep a foot in the door of emerging technologies and to avoid costly vectoring.

Entrainment

It may be useful to further examine the relationship of strategic ambidexterity heuristics with the notions of internal and external timing (Brown and Eisenhardt, 1997). For example, executives may time the switching of a Cyclical heuristic based on internal or external events or other pacing mechanisms. For instance, firms such as Intel entrain other firms in their industries to their pace (e.g., Moore's Law). Sastry (1997) found that a rest

period was needed for firms to absorb changes, increasing the need for pacing strategies or firm clockworks. For instance, the company studied with field research (ABC Inc.) appears to use internally planned events from month to month, from year to year, and in three year cycles to regulate its activities and to maintain highly taut organizational pace.

Conceptualizing Exploration and Exploitation

There has been debate in the literature about whether exploration and exploitation should be conceived as ends of a continuum with inherent tradeoffs or as orthogonal constructs that do not affect each other (Gupta et al., 2006; Simsek, 2009). For example, Uotila et al. (2009) used an orthogonal measure and found that in environments that experience very little technological change and have very low levels of research and development, the tradeoff between exploration and exploitation may be less important. Conversely, the tradeoff may be reduced if a firm has virtually unlimited resources, such as after a highly successful initial public offering. More research may be needed to clarify the conditions under which an orthogonal conception of exploration and exploitation is warranted.

Evolutionary Mechanisms and Motors

Strategic leaders may develop their own heuristics based on their experience about the trajectory of evolution present in their environments. More qualitative work is needed to tease out the heuristics present within managerial mental models (e.g., Brunner et al., 2008; Burgelman and Grove, 2007; Lovas and Ghoshal, 2000; McNamara and Baden-Fuller, 1999). A better understanding of effective heuristics for strategic ambidexterity may help the field to distinguish effective patterns from ineffective patterns of balancing exploration and exploitation over time (Siggelkow and Rivkin, 2009).

Westerman, McFarlan, and Iansiti (2006) argued that differing bases of competition in early and later stages of an innovation's lifecycle call for different organization designs. Apparent lifecycle stages map onto the nonlinear behavior of guided evolution (Lovas and Ghoshal, 2000). Viewing exploration and exploitation as dialectical forces, strategic leaders may develop unique syntheses to synch with and coevolve with their environments (Lewin et al., 1999). Firms may evolve their own heuristics to developed configurations that flow and achieve rhythm (Brown and Eisenhardt, 1997; Hinings and Greenwood, 1988; Vermeulen and Barkema, 2002). Further development of simulations that employ evolution to solve for the best heuristics may be a useful next step for future research. For instance, genetic algorithms can be used to evolve heuristics that use any parameter available from the simulation's memory.

Likewise, various combinations of heuristics within a firm or across firms in an industry may create unpredictable dynamics. Levinthal and March (1993) argue that when many firms enter into exploration phases at the same time, knowledge spillovers will enhance their efforts and increase the chance that an innovation will emerge; for instance, via human resource turnover. This may lead to the situation Burgelman and Grove (2007) called "runaway rule change", where more than one firm simultaneously changes the rules of the game, unless firms confine their exploration to mutual knowledge territories. Future researchers may examine such interactions among firms, whether they are cooperative, collusive, or competitive (Chen and Katila, 2008; Peteraf and Shanley, 1997).

Configurations of heuristics at the industry or field level may also be equifinal in nature (Hill and Birkinshaw, 2008; Raisch and Birkinshaw, 2008). For example, consistent with the notion of equifinality in the stream of research on configurations (e.g., Doty, Glick, and Huber, 1993), an in-depth examination of the heuristics used at 3M Corporation and Intel Corporation may reveal that they are equifinal in the evolution of their firms. In fact, the

ideas of non-linear dynamics may go along with those of asymmetry, which suggest the use of novel methodologies combining qualitative and quantitative methods such as a set-theoretic approach to test configurational theories and draw inferences from a small number of cases (Fiss, 2007; Ragin, 2000). For instance, a dynamic may emerge whereby some firms thrive by diversifying and start using Regular ambidexterity, while others remain focused, but vector successfully at the right time (Burgelman, 2002). More research is needed to better understand how the mere presence of different heuristic combinations alters the dynamics of the environment. If environments change as a result of heuristics, and heuristics are informed by the changes in the environment, then cascading responses are likely to produce a game in which all firms lose. For instance, it would be interesting to get an estimate of the number of repercussions expected by a manager in response to a strategic move.

Conclusion

Most previous research on ambidexterity has focused on structural ambidexterity to the neglect of strategic ambidexterity. My goal in this study was to draw attention to strategic ambidexterity and investigate how firms may use varied temporal approaches in different environments. In particular, my aim was to examine the relative performance of three approaches to strategic ambidexterity—Regular, Irregular, and Cyclical—with respect to the type of rule change environment they inhabit, the level of competitive intensity they experience, the firm's level of product diversification and whether it is proactive or reactive. It required longitudinal data over a long period of time on issues that may be tacit in the minds of top executives.

Insights from the qualitative study suggested, and data generated by the agent-based simulation demonstrated, that different temporal approaches to strategic ambidexterity may work better under some conditions than others. In general, when competence-destroying rule

changes dominate, undiversified firms may need to vector their organizations more dramatically by shifting their resources in response to rule changes (Burgelman, 2002), especially when competitive intensity is high and proactive heuristics are employed. As environments become more prone to competence enhancing innovation, the need for Regular ambidexterity becomes pressing. Too high a level of exploration leads to overextension, too much variety, and, therefore, downward sloping part of the diversification/performance curve (Cyert and March, 1966; Stimpert and Duhaime, 1997). Innovation needs to be constrained to allow the core to grow rapidly enough to pay for itself and all the exploration that failed. The value of innovations cannot be predicted, making it risky to bet the farm on any one of them (Burgelman and Grove, 2007).

As firms become diversified, they may be less likely to suffer devastating losses all at once, reducing the need for vectoring and its associated costs (Burgelman, 2002). But as organizations become increasingly complex, they need to relate their businesses to maintain a cognitive grasp of their environments (Bettis and Prahalad, 1995), or suffer degrading performance (Chandler, 1966). If to vector a firm must shed a large proportion of its core businesses and enter new ones in one great leap, then few large firms may survive this necessity (Burgelman, 2002).

A related environment is less complex (Dess and Beard, 1984; Rivkin, 2000), making it easier for managers to understand it as a whole. This increases the potential magnitude or potency of a rule change for the organization, but only if the rule change is related to the way the firm's businesses are united (Bettis and Prahalad, 1995). Unrelated diversification can reduce the potency of future rule changes but may lower returns and may require the development of new competencies (Rumelt, 1974). This double-edged sword is dulled by changing the organizations to the degree needed, yet no more - that is, matching organizational change to the potency of a rule change (Kim and Rhee, 2009).

The effectiveness of strategic ambidexterity heuristics may depend on windows of opportunity—being too proactive or reactive could be costly (e.g., Volantis' mobile software tools). When should firms such as *Research in Motion* (RIM) begin to think about their new product to replace their existing product (i.e., Blackberry)? Apple comes out with new products more often; should RIM follow suit, or continue to exploit their handset? Apple's product strategy may be linked to its ability to fill multiple niches simultaneously. Apple may be diversifying its risk, while RIM rides the current wave as fast as it can and potentially makes a magnificent switch when it becomes clear (strategic recognition), possibly through alertly observing Apple's experience, which wave (rule change) to catch next. The theory developed herein would suggest that RIM should continue its single business approach if we consider its environment to be mostly dominated by competence-destroying rule change, whereas I would suggest it should start some small exploratory projects right away if we consider its environment to be dominated by competence enhancing rule change. The smart phone, as it currently exists, may be a short-lived cold innovation (McLuhan, 1964). The phone is migrating to the ear, while the Apps are increasing in size. Together they are both degraded, apart, the phone and computer are at their hottest (McLuhan, 1964). An analysis of the specific rules of an industry and its technologies is still required to decide on the type of rule change environment firms face.

This study has shown that following different simple heuristics, firms can gain competitive advantage in different types of environments. More heuristics could be tested to see if there exist even better solutions. For instance, some firms may switch between exploration and exploitation in response to other types of signal not examined herein. Examining firm's proto-heuristics (see Table 5.7) may allow researcher to derive additional heuristics. For instance, ABC Inc. changed from one heuristic to others as it evolved. I

presented four ideal types (Specialist, Regular, Irregular, and Cyclical); However, in reality, firms may combine these into hybrid types.

Artificial intelligence researchers also proposed several heuristics, which they interestingly call exploration/exploitation (E/E) strategies (Wilson, 1996). They have developed algorithms called learning classifier systems (LCSs). The most studied of these appears to be the XCS (Sigaud and Wilson, 2007), which has been used to examine some of the E/E strategies or heuristics in the business context (Rejeb et al., 2005; Wilson, 1996). The proactive dynamic heuristic I modeled after Intel's description by Burgelman and Grove (2007) appears to have robust support for its effectiveness in enhancing corporate longevity and sales performance under certain conditions. However, in future research using E/E strategies provided in the artificial intelligence literature may be useful for extending and refining temporal heuristics for strategic ambidexterity.

This study fills an important gap in the emerging ambidexterity research literature by decomposing the problem of timing exploration and exploitation activities under varying environmental conditions. I hope that this study will encourage others to pay attention to these and related questions, as I have clearly only skimmed the surface of this vast and interesting avenue of strategy research. Our field could possibly be unstuck from its ailing paradigm (Ashforth, 2005) by encouraging simulation as a method of theory elaboration, along with qualitative research and formal modeling, before investing in large data queries (Davis et al., 2007a). This might require changes to doctoral programming. For instance, in most of the physical sciences, simulation is a key method for theory development about natural phenomena (Anderson, 1999). If we admit that business firms and other human systems are also part of nature's web, then we should make the similar shift in methods. By forcing assumptions to be formalized, simulations add to the researcher's clarity of mind by improving their mental models about phenomena (Harrison, et al., 2007). They are useful in

teasing out causal relationships between correlated facts (Cook and Campbell, 1979), which can go a long way in developing a rigorous and relevant science of organizations and their management.

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