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Corporate strategy: an agent-based approach

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Abstract

In this paper, we explore the application of the construct exploitation and exploration at the level of the corporate strategy of the firm. For that purpose, we operationalized and formalized the analysis through the development of a set of agent-based simulations which capture and describe the evolution of firms led by exploitative and explorative corporate strategies in business environments showing different levels of complexity. Results indicate that the relative performances of exploitative strategies *vs* those characterized by an opportunistic combination of exploitation and exploration, are contingent on the characteristics of the environment in which the firm operates and the quality of the corporate strategic plans that determine the initial strategic positioning of the firm.

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Introduction

Corporate-level strategy, or simply ‘corporate strategy’, is a topic that has received much attention since the very early days of the strategic planning field. Andrews (1971) defined corporate strategy as ‘the pattern of decisions that determined a company’s goals, produced the principle policies for achieving these goals, and defined the range of businesses the company was to pursue’. Porter (1987) referred to corporate strategy as ‘what makes the corporate whole add up to more than its business parts’. Despite some controversy around the size of the corporate effect on the performance of multibusiness firms (Schmalensee, 1985; Rumelt, 1991; Brush and Bromiley, 1997; Chang and Singh, 2000; Hawawini *et al*., 2003), the impact of corporate-level decisions on the overall strategy of a multibusiness firm has been widely reported in the strategy literature (Porter, 1987; Goold *et al*., 1995; Collis and Montgomery, 1998; Bowman and Helfat, 2001; Ruefli and Wiggins, 2003).

One of the major concerns of students of corporate strategy has been to identify broad patterns followed by multibusiness companies in their attempt to develop ‘corporate advantage’. In this line, Porter (1987) identified and analyzed generic corporate strategies followed by multibusiness firms. Goold and Campbell (1987) characterized corporate strategies according to the patterns followed by firms at the time of managing jurisdiction over decisions between the corporate level and business units and the way they exercise strategic control when implementing their strategies. Prahalad and Hamel (1990) and Collis and Montgomery (1998) approached corporate strategy from the perspective of the resource-based view of the firm and proposed that successful corporations create corporate advantage by focusing on businesses that benefit from the portfolio of resources and capabilities or ‘core competences’ mastered by the corporation.

This paper follows the path opened in Caldart and Ricart (2004) and aims at shedding new light in the debate on corporate advantage from a different viewpoint. We explore corporate strategy from the point of view of the exploration *vs* exploitation dichotomy (March, 1991). We try to understand under what conditions corporations benefit from following strategies based on evolution strictly bounded by a deliberate corporate strategic plan (exploitation) *vs* those that are open to abandon their initial plans under certain conditions, and develop an exploratory strategy.

For that purpose, we developed a set of agent-based simulations of corporate strategies featuring different characteristics. The simulations, based in Kauffman’s NK model (Kauffman, 1993) permit as to model exploitative and explorative corporate strategies tuning the levels of environmental complexity faced by the firms and the quality of the strategic plans formulated by their top managers.

Our findings are relevant for the debate on the tensions between exploration and exploitation as two opposed logics for strategic evolution. Results show the contingent value of each of exploitative and explorative corporate-level strategies. Strategies based on disciplined exploitation within the boundaries of a strategic plan work better when strategic plans have a high quality and when environments tend to be simple. However, in situations characterized by the combination of a complex environment and management's limited understanding of the strategic alternatives available for the firm, opportunistic strategies that shift from exploitation to exploration, in line with the punctuated equilibrium paradigm, are the best performers.

These results are also relevant for the long lasting debate on the relative merits of self-restraint *vs* opportunistic adaptation as opposite strategic behaviors (Mintzberg, 1990; Ansoff, 1991). Finally, our results give formal support to previous descriptive work arguing the superiority of loose, self-organized collaboration between business units over centrally imposed, tightly coupled collaboration initiatives, at the time of searching for corporate advantage through intra-firm collaboration (Brown and Eisenhardt, 1998; Galunic and Eisenhardt, 2001).

This paper starts with an outline of different streams of work based explicitly or implicitly in the exploration and exploitation analytical construct. Then, we introduce and explain a set of agent-based simulations that permit to formalize the study of firms following exploitative and explorative corporate strategies. In the following section, the results of the simulations are analyzed and discussed. Finally, we present our conclusions and recommendations.

Creating corporate advantage: the dynamics of continuity and change

Caldart and Ricart (2004) approached the field of corporate strategy from an evolutionary perspective (Figure 1). They viewed corporate strategy as a process driven by three interlinked processes. First, corporate managers develop a representation of the problem space of the firm that results in the formulation of a corporate strategic plan. Then, the firm implements such plan making a choice on whether to prioritize an exploitative development of the initial plan (dynamics of continuity) or to engage in an opportunistic combination of exploitation and exploration (dynamics of change). Finally, this approach focuses on insights derived from complexity theory stating that the firm frames their corporate strategy through choices of structural designs of varying degrees of differentiation and integration (Lawrence and Lorsch, 1967).

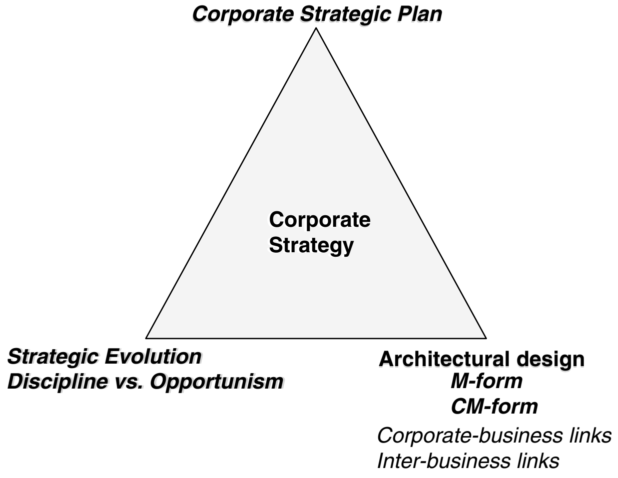

Figure 1 Corporate strategy triangle (adapted from Caldart and Ricart, 2004).

Studies on issues related to the dynamics of continuity and change have a long tradition in organization studies. Scholars have long distinguished between structures designed for efficiency and those designed for innovation. For instance, Buckley (1967) distinguished two basic sets of systems processes: morphotasis and morphogenesis. Morphotasis refers to those processes that tend to preserve or maintain a system's given form or structure. In social systems it refers to socialization and control activities. Morphogenesis refers to those processes that elaborate or change the system, for example, growth, learning and differentiation. Similarly, single-loop *vs* double loop learning (Argyris and Schon, 1978), feed forward and feedback processes (Crossan *et al.*, 1999) and local search *vs* long jumps (Gavetti and Levinthal, 2000) are differentiated in the organizational learning literature. Burgelman's (2002) internal ecology model distinguishes between variation-reducing induced processes and variation-increasing autonomous processes. Finally, in the context of managerial economics, Ghemawat and Ricart (1993) make the distinction between static efficiency, a continuous search for improvement along a fixed production function, and dynamic efficiency, a discontinuous shift from a production function to another that is more profitable.

Among all these approaches, the conceptual distinction between exploration and exploitation has emerged as a widely used analytical construct at the time of addressing issues related to continuity and change in organization studies (March, 1991; Crossan *et al.*, 1999; He and Wong, 2004). Exploration and exploitation have been proposed in the literature as two qualitatively different learning activities between which firms divide attention and resources and develop competences. Exploration is about creating variety in experience, and implies firm behavior characterized by discovery, risk taking, variation, experimentation and innovation (March, 1991). In general, it is associated with organic structures, loosely coupled systems, path breaking and emergence. Exploitation is about creating reliability in experience and implies firm behavior characterized by refinement, efficiency, selection and implementation, (March, 1991). It is associated with mechanistic structures, path dependence, routinization, bureaucracy and stability. Returns associated with exploration are riskier and distant in time, while those associated with exploitation are more certain and closer in time. By generating larger variation, explorative firms are expected to experience substantial success as well as failure, while exploitative firms are likely to generate more stable performance.

The importance of maintaining an appropriate balance between exploration and exploitation has been deemed as a primary factor in firm's survival and prosperity (March, 1991). This need of a balance has been labeled as *ambidexterity* (Tushman and O'Reilly, 1996; Birkinshaw and Gibson, 2004). However, other authors cast doubts on the convenience of such simultaneity of exploitation and exploration, favoring instead *punctuated equilibrium* (Gersick, 1991; Burgelman, 2002). This idea refers to a temporal rather than organizational differentiation and suggests that cycling through periods of exploitation and exploration is a more viable approach than a simultaneous pursuit of the two (Gupta *et al*., 2006).

In sum, the decision on whether to emphasize strategic continuity, or strategic renewal, demands fundamentally different logics at the time of setting the overall strategic direction of the firm and allocating its scarce resources. In this paper, we focus on the temporal differentiation perspective between both logics embedded in the idea of punctuated equilibrium.

An agent-based model of exploitative and explorative corporate strategies

Being our intention to study evolutionary adaptation through time, we require a setup based on an algorithmic approach, providing detailed instructions on how firm's behavior adjusts as the search process unfolds. Additionally, agents must be considered as individuals, as different agents can evolve and learn in different ways. These two features, algorithmic updating and heterogeneity of agents are best handled by computation. Agent-based computational models permit to address such features, constituting a powerful research method for theory development based on more realistic assumptions than closed form solutions and allowing the flexibility to accommodating out-of-equilibrium behavior (Axelrod, 2006).

In an agent-based model, individual agents autonomously adapt making decisions based on internal rules and local information. Not being constrained by the imposition of equilibrium conditions, these models offer a degree of flexibility that permit to represent firms as a system composed by many parts that (a) interact nonlinearly; (b) show tunable degrees of interdependence that constrain the ability of the firm to adapt, and (c) produce emergent behavior. These models build on the tradition of the behavioral theory of the firm (March and Simon, 1958; Cyert and March, 1963) and evolutionary theory (Nelson and Winter, 1982). The behavioral theory of the firm conceives firms as entities that engage in problem solving through processes of search and discovery. Unlike the classic theory of the firm, which treats firms as omniscient rational systems, behavioral theory assumes that, while searching for solutions to their problems, firms adopt some form of adaptive behavior. While adapting, they consider only a limited number of decision alternatives, due to bounded rationality (Simon, 1997). In the same line, recent work (Rivkin, 2000; Moldoveanu and Bauer, 2004) showed that strategy formulation is an intractable problem. Being managers unable to write an algorithm that will enable them to locate the best set of choices in reasonable time, they strategize trying to satisfy multiple criteria rather than optimizing.

The concept of adaptive search is meaningful only in the context of a defined search space, a means for moving through such space, and the ability to determine the quality of a proposed solution. Kauffman's NK model (Kauffman, 1993) provides such a context and so has become the mainstream formal modeling strategy for recent work rooted in the evolutionary tradition. Work based on the NK model has been developed and adapted by organization theorists to model organizational problem-solving processes showing features such as bounded rationality in the consideration of alternatives, the existence of interdependencies between subunits that can be manipulated by planning systems, decision making based on analogy, and the existence of decision rules that bound the set of possible choices (Levinthal, 1997; Gavetti and Levinthal, 2000; Rivkin, 2000; Gavetti *et al*., 2005; Lenox *et al*., 2006).

In the NK model, organizations adapt by modifying their existing form in an attempt to enhance their performance in a *fitness landscape* (Kauffman, 1993). A fitness landscape, usually referred as a *performance landscape* in the management literature (Siggelkow and Levinthal, 2003, 2005) consists of a multidimensional space in which each attribute of the organization is represented by a dimension of the space and a final dimension indicates the performance level of the organization. In the NK model, the parameter N expresses the number of attributes that characterize the entity (in our case, the attributes are decisions and the entity is a business firm). The overall behavior of the firm is characterized by the vector $X\{X_1, X_2, \ldots, X_N\}$, where each X_i takes the value of 0 or 1. Then, the performance landscape consists of a map of the 2^N possible performance values associated with each of the policy choices the firm can make. The parameter K is a measure of the number of policies that affect a particular policy's contribution to performance. In other words, K is a measure of the degree of interdependence between the firm's different policies. Then, each attribute of the vector X can take on 2^{K+1} different performance values, depending on the value of the attribute itself (either 1 or 0) and the value of the K other attributes with which it interacts.

Interdependencies between attributes affect the topography of the performance landscape. In the extreme case of $K=0$, the contribution of each policy is independent of other policies. Therefore, an absolute optimum can be reached simply by optimizing individual decisions, being the overall performance a simple aggregation of their individual contributions to performance. In this situation, we say that the landscape tends to assume a single-peak configuration. In these kinds of landscapes, the performance values of one-mutant neighbors are highly correlated.

As the value of K increases, so does the *ruggedness* of the landscape, that is, the landscape will have more local maxima or 'peaks'. In a rugged landscape, actors are usually assumed to be intelligent, but their intelligence is local to their position on the landscape (March and Simon, 1958; Cyert and March, 1963). They are typically able to identify the positive and negative gradients around their current position, but not of making similar judgments about more distant positions (Levinthal and Warglien, 1999). In this case, firms may become trapped in competency traps (Levitt and March, 1988). In the extreme case of $K=N-1$, the performance landscape is entirely uncorrelated and the number of local performance optima is very large.

In light of the above, in order to develop a simulation model of adaptive firms led by different strategic postures

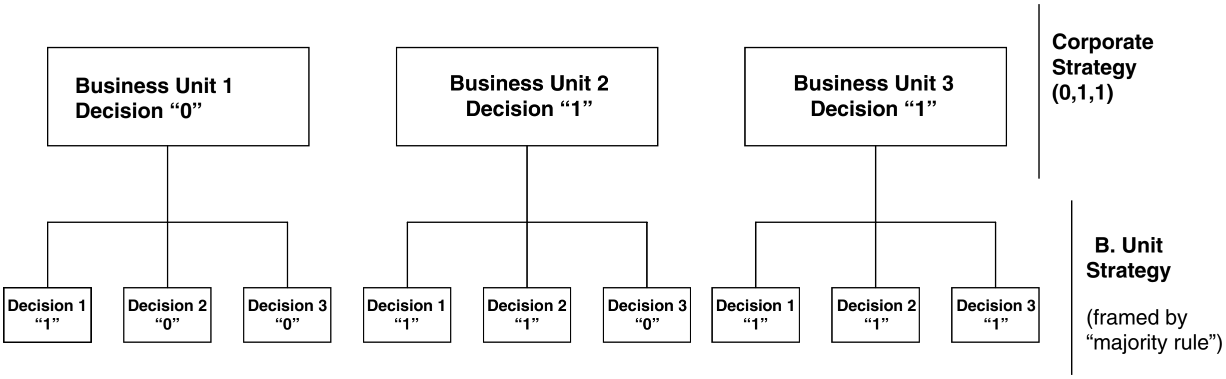

Figure 2 Example of decision making at corporate and divisional levels.

(exploitation or exploration), we must: (a) generate the performance landscapes over which adaptive search processes take place; (b) determine how firms position themselves at the beginning of the search process; and (c) explain how they evolve over time according to their strategic posture and the structural complexity of their architectural designs.

Modeling the performance landscape

Modeling the performance landscape implies mapping the 2^N performance values associated with each possible configuration of decisions, represented by the vector $X\{X_1, X_2, \ldots, X_N\}$ that firms can choose during their evolution. In the NK model the performance associated with each strategy equals the average of the contribution to performance of each of the N decisions (Rivkin, 2000).

In this paper we refer to each of the different configurations of the vector as a specific *strategy* followed by the firm (Rivkin, 2000). In this way, we build on previous work that relied on the NK model as a framework to deal with strategy issues. For instance, McKelvey (1999) assimilated the parameter N to activities of the company's value chain (Porter, 1985) and stated that the value of the parameter K is a strategic choice made by the firm. Gavetti *et al.* (2005) also use an adaptation of the NK model to simulate how firms choose their strategies by analogy and follow strategic trajectories that can be either orthodox (self-restraint by an initial formulation) or heterodox (unbounded local search in the performance landscape).

Corporate and business decisions

As we focus on corporate-level strategy, we need to develop a model that links corporate decisions to business unit decisions. Corporate decisions set the parameters of decisions made in the business units, imposing restrictions on decision makers at that level (Milgrom and Roberts, 1992). We operationalized this relationship between decision levels by clustering the N attributes within the vector in U subgroups, each of which represents a business unit of a multibusiness firm. Within each subgroup or division, D attributes represent the decisions made within that business unit.[1] In our simulations, we model a firm with $N=9$, with variables clustered in three business units, $U1$, $U2$ and $U3$. Therefore, we can model 2^3 different corporate strategies. Each business unit can then make three decisions, $D1$, $D2$ and $D3$. Decisions made at the corporate level are related to decisions made within the business unit by a simple 'majority rule' (Gavetti *et al.*, 2005). For instance, if the corporate decision for $U1$ is '1', the possible decisions within $U1$ that fit such corporate decision are only {1 1 1}, {1 1 0}, {0 1 1} or {1 0 1}. Figure 2 provides an example of how the majority rule works.[2]

Computing the contribution to performance of individual decisions

In order to calculate the performance associated with each strategy, we need to compute the performance contribution of each of the firm's decisions for each possible strategy. To do that, we need to model how interdependencies between decisions at the corporate level and at the business level impact on the performance contribution of the firm's attributes. Additionally, we need to determine how corporate decisions affect business-level decisions. Following Gavetti *et al.* (2005), we modified Kauffman's basic framework by replacing parameter K by two parameters, K_W and K_B. Parameter K_W captures interdependencies within each business unit. Parameter K_B measures the degree of interdependence of decisions made by the different business units. Appendix 1 includes a step-by-step explanation of the computation of the performance contribution of each decision and of the overall performance of the firm.

Modeling the initial positioning of the firm

After developing the performance landscape over which firms' adaptive evolution takes place, we need to model how do firms position themselves at the beginning of the simulation (M_0). We refer to this initial positioning in the model as the firm's 'strategic plan'. In order to model strategic choice at M_0 in the simulation model, we proceeded in the following way. As $N=9$ and $U=3$, the firms we modeled can only follow 2^3 'generic' corporate strategies. Each of these strategies has the effect of bounding the firm's evolution within the sub-area of the performance landscape that satisfies the majority rule imposed by the specific corporate strategy the firm has chosen. We computed the expected value of the performance that the firms can achieve in each of those sub-areas of the performance landscape corresponding to the eight possible corporate strategies that a firm can choose. Then, we used that information to model the initial positioning for the different firms in the simulation. At the beginning of the experiment (M_0), the computer program randomly assigns to each firm a number C of possible corporate strategies, with $0 < C \leqslant 8$. Simulated firms position themselves at M_0, choosing, the corporate strategy with the highest associated expected value out of the C alternative corporate strategies that have been represented to the firm by the computer. It is worth highlighting that, although the corporate strategies represented and chosen by the firms at M_0 are grounded on the actual landscape, they are based only on knowledge of the expected values of the performances associated with the respective sub-areas of the landscape. Therefore, these representations are not a good predictor of the performance of specific strategies in the sub-set of the performance landscape chosen by the firm. Although the chosen corporate strategy is, on average, the best of the C strategies that firms can represent, this does not mean that all the points in the subset of the performance landscape chosen by the firm are attractive. This design is consistent with the assumption of bounded rationality of firms as adaptive rational systems (March and Simon, 1958; Cyert and March, 1963; Levitt and March, 1988; Levinthal and March, 1993; Simon, 1997). In our case, simulated firms might experience a competency trap (Levitt and March, 1988), despite evolving in a subset that is, on average, relatively attractive.

In order to enrich our model, we modeled firms led by Strategic Plans of different qualities. A group of firms choose their initial positions having a high degree of awareness of the possible strategies they can choose. We labeled these firms as *High Quality Strategic Planners* (HQSP) and modeled them in the following way. At M_0, these firms 'know' the expected values of all the possible corporate strategies they can choose ($C = 8$) and adopt the one with the highest associated expected value.

The second kind of Strategic Plans corresponds to firms with a limited understanding of their possible strategic choices. We labeled these firms as *Low Quality Strategic Planners* (LQSP) and modeled this limited awareness of alternatives by letting them represent only the value of a fraction of all the corporate strategies available ($C = 3$). Firms then choose the positioning with the highest associated expected value out of the ones they can represent from this limited sample.

Modeling exploitation and exploration

After modeling the initial strategic plan, we need to operationalize exploitation and exploration in the simulation. We proceeded in the following way. We say that a firm follows a strategy of exploitation when it evolves within the boundaries set by the initial strategic plan. Contrarily, we say that a firm follows a strategy of exploration when its search strategy is not subject to the self-restraint imposed by the initial positioning embedded in the strategic plan. Based on these two definitions, we modeled the following two broad patterns of evolution:

Disciplined evolution: These firms' strategies are self-restraint by the boundaries of the initial Strategic Plan throughout the whole simulation. The majority rule embedded in the corporate strategy chosen at M_0 bounds the decisions made within the business units throughout the experiment.

Opportunistic evolution: These firms also evolve initially within the discipline provided by the initial positioning they chose at M_0. However, if after a T number of iterations, the firm fails to increase its performance, it abandons the constraints imposed by the majority rule and evolves throughout whole performance landscape without any restriction. In this way, the failure of the initial corporate strategy to perform, leads the firm to abandon the self-restraint exploitative strategy and engage in exploration beyond the boundaries of the initial plan. In our study, we modeled two alternatives of the Opportunistic Evolution. This allowed us to observe the performance of 'Highly Opportunistic' firms, which abandon the initial corporate strategy relatively quickly if it does not lead to improved performance ($T = 4$), and of 'Moderately Opportunistic' firms, which abandon their original strategy only after a longer period of failure to improve performance ($T = 8$).[3]

Modeling architectural design

Having discussed the way corporate strategies are chosen by the firms modeled in the agent-based simulation and how these firms evolve through the experiment, in this section we explain our choices of environmental conditions faced by the firms. In this way we will be able to observe how different corporate strategies perform in different kinds of environments. Specifically, we modeled scenarios with different degrees of complexity. In the model, we consider that environmental complexity is reflected in the architectural design of the firm, more specifically, in the interdependence among the decisions that a firm faces. In this way, we assume that interdependences are not chosen by the firm but are dictated by the nature of the decisions themselves, then the complexity of a firm's architectural design reflects the degree of environmental complexity faced by the firm. This assumption is consistent with Ashby's law of requisite variety[4] and Lawrence and Lorsch's Integration and Differentiation framework (Lawrence and Lorsch, 1967). Recent work based on the performance landscapes framework (Siggelkow and Rivkin, 2005) also operationalized environmental complexity in the way we propose. As the focus of our paper is corporate-level strategy, we operationalized interdependence by tuning the value of parameter K_B, the measure of the level of interdependence between the business units. As stated above, this parameter can take any value between 0 and 1. Thus, firms with $K_B = 0$ and $K_B = 0.25$ are considered to be firms operating in Simple and Relatively Simple Environments (corresponding to *Low Environmental Complexity*). Firms with $K_B = 0$ have an M-form structure (Chandler, 1962), while firms with $K_B = 0.25$ have a moderately integrated CM-form structure (Hill, 1988). A firm whose decisions are highly interdependent is deemed to be operating in a complex environment (corresponding to *High Environmental Complexity*). In our model, these are firms for which $K_B = 0.5$ (Relatively Complex) and $K_B = 0.75$ (Complex). These firms represent a highly integrated version of the CM-form structure. Interdependences within business units are tuned by the parameter K_W. As K_W is a measure of the number of links between the business units' attributes, with $D = 3$, as in our model, K_W can take only three values: 0, 1 and 2 as, by definition, $K_W < D$.[5]

Figure 1, is useful to integrate and synthesize our preceding discussion on the modeling of corporate strategy by representing the three building blocks that constitute our agent-based model of Corporate Strategy. These building blocks are, first, a strategic plan based on the cognitive representation of the alternative corporate strategies that the firm can choose in its performance landscape. Second, firms choose a corporate search strategy, defined by the degree of discipline/opportunism followed by the firm with respect to its original strategic plan. Finally, the corporate strategy is completed by choosing an architectural design that addresses the level of environmental complexity faced by the firm.

Architecture of the simulation

In Table 1 we list the different 'families' of landscapes included in the simulation models. Each family corresponds to combination of (a) a different topography of the performance landscape, that is, the different combinations of the parameters K_B and K_W included in the model and (b) different qualities of strategic plans (HQSP and LQSP).

For each of these 16 families, we model Disciplined, Highly Opportunistic and Moderately Opportunistic firms. In addition, within each family we also included an additional set of firms that evolve through pure exploration and do not position at M_0 according to a strategic plan but randomly. We label these firms as 'Pure Exploration' ones. Despite this is clearly an unrealistic case, as no firm determines its corporate strategy randomly, we included it in the model in order to compare the results of these 'strategy-less' firms purely led by exploration since M_0 with those of their peers who position themselves intelligently.

Table 1 Description of families of firms included in the simulations

	Corporate plan	*Architectural design*
1	High Quality Strategic Planner	$K_B = 0$; $K_W = 1$
2	Low Quality Strategic Planner	$K_B = 0$; $K_W = 1$
3	High Quality Strategic Planner	$K_B = 0$; $K_W = 2$
4	Low Quality Strategic Planner	$K_B = 0$; $K_W = 2$
5	High Quality Strategic Planner	$K_B = 0.25$; $K_W = 1$
6	Low Quality Strategic Planner	$K_B = 0.25$; $K_W = 1$
7	High Quality Strategic Planner	$K_B = 0.25$; $K_W = 2$
8	Low Quality Strategic Planner	$K_B = 0.25$; $K_W = 2$
9	High Quality Strategic Planner	$K_B = 0.5$; $K_W = 1$
10	Low Quality Strategic Planner	$K_B = 0.5$; $K_W = 1$
11	High Quality Strategic Planner	$K_B = 0.5$; $K_W = 2$
12	Low Quality Strategic Planner	$K_B = 0.5$; $K_W = 2$
13	High Quality Strategic Planner	$K_B = 0.75$; $K_W = 1$
14	Low Quality Strategic Planner	$K_B = 0.75$; $K_W = 1$
15	High Quality Strategic Planner	$K_B = 0.75$; $K_W = 2$
16	Low Quality Strategic Planner	$K_B = 0.75$; $K_W = 2$

Four types of firms are used in each landscape/corporate plan combination: Disciplined, Highly Opportunistic, Moderately Opportunistic, and Pure Exploration.

In order to ensure that the results reflect the underlying structure of the simulation model and not just particular cases of a highly stochastic process, we proceeded in the following way. For every set of parameters K_W and K_B a landscape is generated. In that landscape, 25 firms of each of the seven kinds of firms corresponding to the chosen set of parameters are released during the 30 'moves'. The average performance value for each kind of firms in each period is recorded in that landscape. Then, another landscape is generated and other seven sets of 25 firms are released. This operation is repeated for 500 landscapes. This process is repeated for each of the landscapes corresponding to all the combinations of the parameters K_W and K_B included in the model (see Table 1). Therefore, for every set of parameters, the performance value of each kind of firms will be composed of the average of 500 experiments on different fitness landscapes, each averaging 25 firms per type of evolution pattern. This large number of simulation trials reassures the robustness of the simulation. We also assessed the robustness of this design by testing the significance of the differences between the means of 10 samples of performance values for random positioning in the performance landscape, calculated as described above, with respect to the population mean (the population mean μ for the performance of a firm positioned randomly equals 0.50). Differences between the sample means and μ were non-significant in all the samples (P-values ranged between 0.14 and 0.79, two sided tests). Finally, the simulations span the full range of parameter values for K_W and K_B.

Analysis

Table 2 describes the performance of each corporate style for eight of the families of landscapes studied. The results reported correspond only to $K_W = 1$. We also modeled the same firms for $K_W = 2$, but for the sake of simplicity we did not include them in the table as results are totally consistent with those for $K_W = 1$. Table 3 shows the differences, in percent, between the most successful style and the rest of the styles for the different kinds of environment.

Disciplined strategies, based on pure exploitation, show the best performance for the HQSP firms operating in low complexity environments (Quadrant I, Tables 2 and 3). Although both Opportunistic strategies ($T = 4$ and $T = 8$) firms start on average from the same initial position as Disciplined firms, they 'pay' for their opportunistic departure from their initial corporate strategy by edging away from their Disciplined peers once they start to pursue strategic explorations outside their original focus. Consistent with these results, Moderately Opportunistic firms ($T = 8$) outperform Highly Opportunistic ones ($T = 4$). In this scenario, Pure Exploration firms improve fast but cannot compensate for their initial disadvantage, due to the fact that they do not rely on any strategy and position at M_0 randomly. They show the poorest performance. These results were consistent for different levels of interdependence within each of the business units, that is, for $K_W = 1$ and $K_W = 2$.

In complex environments ($K_B = 0.5$ and $K_B = 0.75$) with HQSP firms, (Quadrant II, Tables 2 and 3) results follow the same pattern as in Quadrant I. Disciplined is the most rewarding strategy, both for $K_B = 0.5$ and $K_B = 0.75$, with

Table 2 Simulation results: absolute performances

		Corporate strategic plan									
		High Quality Strategic Planners					*Low Quality Strategic Planners*				
		II					*IV*				
Environmental complexity	High	$K_B = 0.75$ $K_W = 1$	M_0	M_{10}	M_{20}	M_{30}	$K_B = 0.75$ $K_W = 1$	M_0	M_{10}	M_{20}	M_{30}
		Disciplined	0.677	0.701	0.708	0.711	Disciplined	0.607	0.631	0.638	0.641
		Opportunistic $T = 4$	0.677	0.698	0.700	0.701	Opportunistic $T = 4$	0.607	0.646	0.673	0.686
		Opportunistic $T = 8$	0.677	0.701	0.704	0.705	Opportunistic $T = 8$	0.607	0.634	0.663	0.681
		Pure exploration	0.500	0.637	0.669	0.684	Pure exploration	0.500	0.637	0.669	0.684
		$K_B = 0.5$ $K_W = 1$	M_0	M_{10}	M_{20}	M_{30}	$K_B = 0.5$ $K_W = 1$	M_0	M_{10}	M_{20}	M_{30}
		Disciplined	0.620	0.669	0.682	0.689	*Disciplined*	0.572	0.620	0.634	0.640
		Opportunistic $T = 4$	0.620	0.662	0.667	0.671	Opportunistic $T = 4$	0.572	0.625	0.645	0.656
		Opportunistic $T = 8$	0.620	0.669	0.676	0.678	Opportunistic $T = 8$	0.572	0.620	0.636	0.655
		Pure exploration	0.501	0.607	0.636	0.650	Pure exploration	0.500	0.601	0.636	0.650
		I					*III*				
	Low	$K_B = 0.25$ $K_W = 1$	M_0	M_{10}	M_{20}	M_{30}	$K_B = 0.25$ $K_W = 1$	M_0	M_{10}	M_{20}	M_{30}
		Disciplined	0.570	0.645	0.665	0.675	Disciplined	0.543	0.616	0.636	0.646
		Opportunistic $T = 4$	0.570	0.636	0.645	0.652	Opportunistic $T = 4$	0.543	0.613	0.630	0.641
		Opportunistic $T = 8$	0.570	0.645	0.656	0.660	Opportunistic $T = 8$	0.543	0.617	0.634	0.643
		Pure exploration	0.501	0.592	0.619	0.633	Pure exploration	0.501	0.592	0.619	0.633
		$K_B = 0$ $K_W = 1$	M_0	M_{10}	M_{20}	M_{30}	$K_B = 0$ $K_W = 1$	M_0	M_{10}	M_{20}	M_{30}
		Disciplined	0.549	0.648	0.672	0.685	Disciplined	0.533	0.631	0.656	0.669
		Opportunistic $T = 4$	0.549	0.639	0.655	0.664	Opportunistic $T = 4$	0.533	0.625	0.646	0.658
		Opportunistic $T = 8$	0.549	0.649	0.665	0.672	Opportunistic $T = 8$	0.533	0.631	0.651	0.661
		Pure exploration	0.501	0.601	0.633	0.650	Pure exploration	0.501	0.601	0.633	0.650

Table 3 Simulation results: relative performances. Differences in performance with respect to the best strategy

		Corporate strategic plan									
		High Quality Strategic Planners					*Low Quality Strategic Planners*				
		II					*IV*				
Environmental complexity	High	$K_B=0.75$ $K_W=1$	M_0	M_{10}	M_{20}	M_{30}	$K_B=0.75$ $K_W=1$	M_0	M_{10}	M_{20}	M_{30}
		Disciplined					Disciplined	0.00%	2.38%	5.49%	7.02%
		Opportunistic $T=4$	0.00%	0.43%	1.14%	1.43%	Opportunistic $T=4$				
		Opportunistic $T=8$	0.11%	0.00%	0.57%	0.85%	Opportunistic $T=8$	0.00%	1.89%	1.51%	0.73%
		Pure exploration	35.40%	10.05%	5.83%	3.95%	Pure exploration	21.40%	1.41%	0.60%	0.29%
		$K_B=0.5$ $K_W=1$	M_0	M_{10}	M_{20}	M_{30}	$K_B=0.5$ $K_W=1$	M_0	M_{10}	M_{20}	M_{30}
		Disciplined					Disciplined	0.00%	0.81%	1.74%	2.50%
		Opportunistic $T=4$	0.00%	1.06%	2.25%	2.68%	Opportunistic $T=4$				
		Opportunistic $T=8$	0.00%	0.00%	0.89%	1.62%	Opportunistic $T=8$	0.00%	0.81%	1.42%	0.15%
		Pure exploration	23.75%	10.21%	7.23%	6.00%	Pure exploration	14.40%	3.99%	1.42%	0.92%
		I					*III*				
	Low	$K_B=0.25$ $K_W=1$	M_0	M_{10}	M_{20}	M_{30}	$K_B=0.25$ $K_W=1$	M_0	M_{10}	M_{20}	M_{30}
		Disciplined					Disciplined				
		Opportunistic $T=4$	0.00%	1.42%	3.10%	3.53%	Opportunistic $T=4$	0.00%	0.59%	0.95%	0.81%
		Opportunistic $T=8$	0.00%	0.00%	1.37%	2.27%	Opportunistic $T=8$	0.00%	−0.11%	0.36%	0.40%
		Pure exploration	13.77%	8.95%	7.43%	6.64%	Pure exploration	8.38%	4.10%	2.79%	2.05%
		$K_B=0$ $K_W=1$	M_0	M_{10}	M_{20}	M_{30}	$K_B=0$ $K_W=1$	M_0	M_{10}	M_{20}	M_{30}
		Disciplined					Disciplined				
		Opportunistic $T=4$	0.00%	1.41%	2.60%	3.16%	Opportunistic $T=4$	0.00%	0.91%	1.60%	1.72%
		Opportunistic $T=8$	0.00%	0.14%	1.05%	1.93%	Opportunistic $T=8$	0.00%	0.00%	0.85%	1.23%
		Pure exploration	9.58%	7.82%	6.16%	5.38%	Pure exploration	6.39%	4.94%	3.63%	2.92%

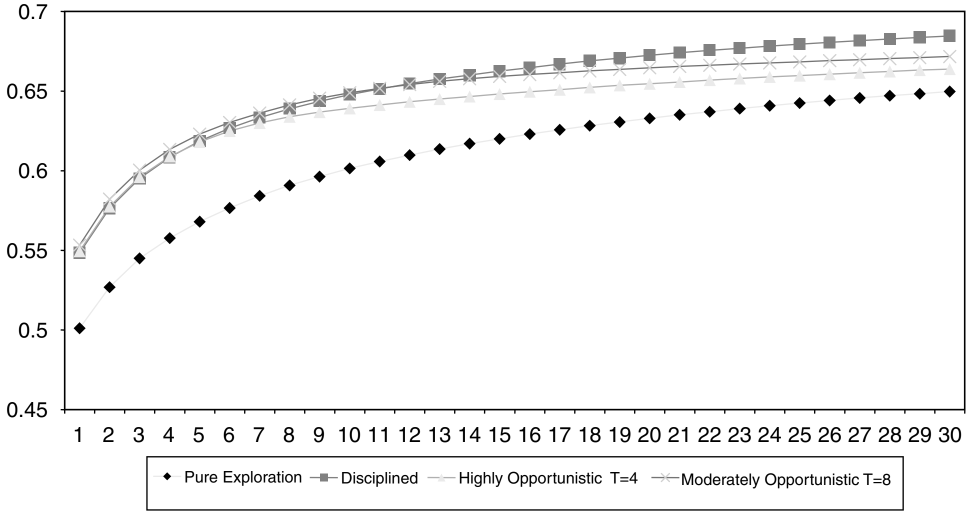

Figure 3 Evolution of performance ($K_W = 1$ and $K_B = 0$).

$K_W = 1$ and $K_W = 2$. In Table 3, however, we can see that, especially for $K_B = 0.75$, the gap between the performance of Disciplined and the two Opportunistic styles narrows with respect to the previous case. The gap between the two Opportunistic variants also narrows. In these kinds of environments, strategy-less Pure Exploration firms are again the poorest performers.

For LQSP firms operating in simple environments ($K_B = 0.0$ and $K_B = 0.25$), the Disciplined style again shows the strongest performance (Quadrant III, Tables 2 and 3). In the case of $K_B = 0.25$ (CM-form), however, the gaps between the results of SP and SC are narrower than in the Complex/High Quality situation, indicating that the decision to be opportunistic can, in this situation, lead to almost the same result as that of Disciplined. For $K_B = 0.25$ and $K_W = 1$, the difference in performance at M_{30} is only 0.40%, compared to differences ranging from 0.85 to 2.27% in the situations discussed above.

The relative performances of the different corporate strategies change dramatically in Quadrant IV, as it can be seen in Tables 2 and 3. For LQSP firms operating in complex environments flexibility seems to be more critical as a key success factor than the quality of the initial positioning. The Highly Opportunistic strategy, which scored third in the three environments discussed above, is the top performer, followed by the Moderately Opportunistic strategy style in the less interdependent case ($K_B = 0.5$). A proof of the value of flexibility is the fact that the performance of the Pure Exploration strategy, despite its poor 'blind' initial positioning, is higher than that of the Disciplined firms and even defeats the Moderately Opportunistic ones at M_{30} ($K_B = 0.75$). Flexibility becomes increasingly valuable feature in situations where plans are poor and complexity makes evolution more difficult due to the suppressing effects[6] resulting from the increased interdependences between the business units. In both cases Disciplined, the most rewarding strategy in the previous three quadrants, shows the poorest performance (7.02% below the Highly Opportunistic strategy for $K_B = 0.75$ and $K_W = 1$ at M_{30}).

Our findings can be summarized as follows. In environments characterized by a low level of complexity and High Quality Corporate Plans, the self-restraint embedded in the Disciplined strategy is a valuable feature (Figures 3 and 4). Sophisticated strategy formulation gives a firm a decisive advantage over rivals that, while departing from the same strategy, at some point decide to engage in exploration. Moreover, low complexity makes it easier for the firm to evolve through local search, thus limiting the potential downsides of the lack of strategic flexibility. An Opportunistic style firm cannot overcome through the higher flexibility of its explorative approach the loss of a well-grounded initial strategic direction. The value of the initial positioning becomes smaller as complexity, measured by K_B and K_W, increases, making flexibility more relevant. A proof for that is that the obviously disadvantaged Pure Exploration strategy, created just for purposes of control, closes the performance gap with respect to the others as K_B and K_W become higher.

The situation changes radically when the complexity of the architectural design is relatively high or high (Figures 5 and 6). In these cases, the relative performance of firms is contingent upon the quality of the initial strategic plans. For High Quality Strategic Plans, the different postures rank in the same order as in low complexity environments. However, though the trade-off between the benefits of disciplined execution of a well-formulated strategy and the benefits of strategic flexibility continue to favor the former, the gap between the two is narrower as suppressing effects penalize the loss of degrees of freedom derived from self-restraint.

For Low Quality Strategic Plans, and high environmental complexity ($K_B = 0.5$ and $K_B = 0.75$), the results of the trade-off between self-restraint and flexibility invert radically. The best results belong to the Highly Opportunistic strategy, a strategy that rapidly sacrifices strategic discipline if the firm fails to make consistent progress in the short term. In this context the combination of a rigid strategy led by poor strategic plan and the difficulty of evolving due to the high suppressing effects embedded in a

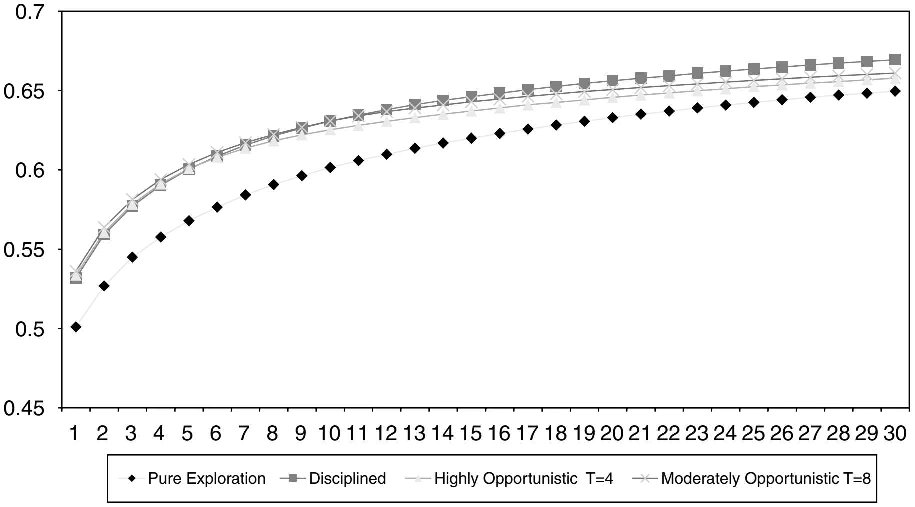

Figure 4 Evolution of performance ($K_W = 1$ and $K_B = 0.0$).

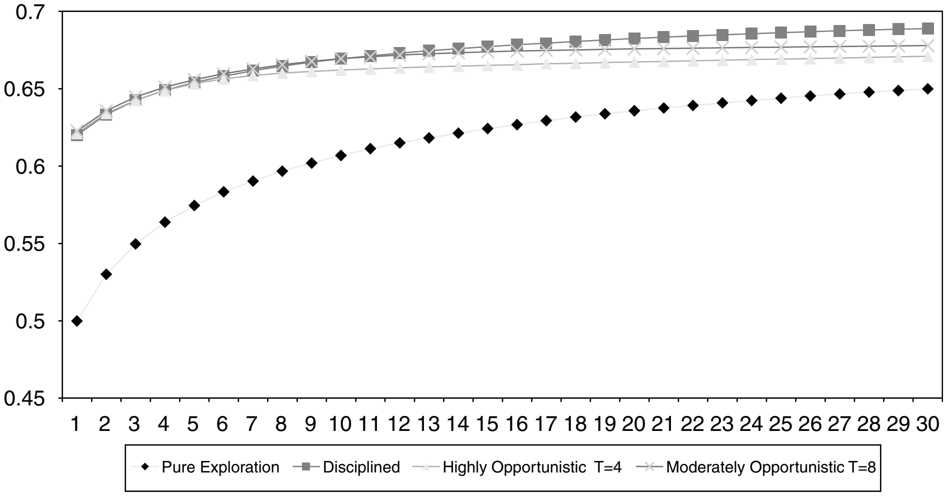

Figure 5 Evolution of performance ($K_W = 1$ and $K_B = 0.5$).

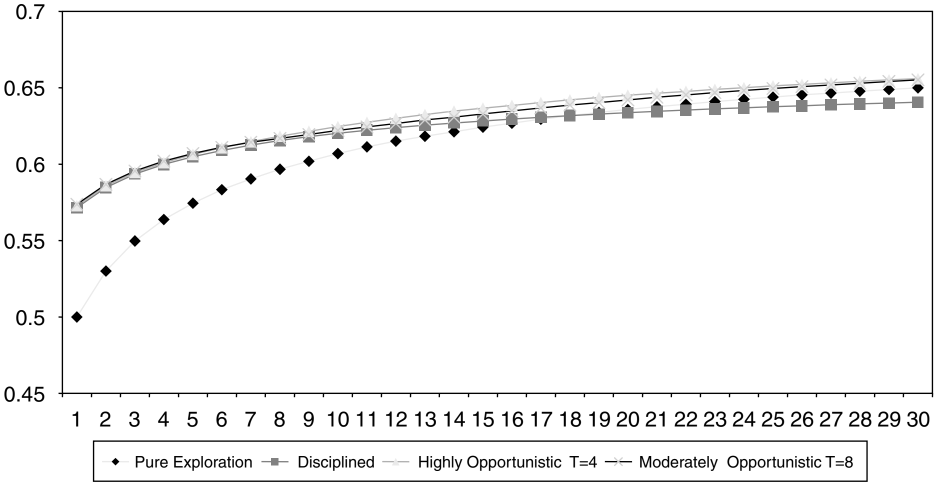

Figure 6 Evolution of performance ($K_W = 1$ and $K_B = 0.5$).

complex architectural design make the Discipline strategy the poorest performer.

Discussion and conclusions

The purpose of this paper was to approach corporate strategy, especially the issue of how can corporate advantage be developed, using the theoretical lenses provided by the construct exploration and exploitation. For this purpose, we formalized the phenomena using agent-based simulations based in the performance landscapes framework. Agent-based simulations based on Kauffman's NK model allow us to model how emerging properties of an evolving entity derived from interaction between its different parts affect its performance. Thus, they constitute a modeling strategy that narrows the gap between closed-form solutions that consider firms as omnisciently rational entities and descriptions from empirically grounded theory.

This method allows us to model firms as adaptive systems with bounded rationality, as described by Cyert and March (1963). By approaching organizational problems through this modeling strategy we improve our understanding of how the features that constitute a particular strategic posture interact and affect the firm's performance as its adaptive process unfolds. With our model we can distinguish the relative performance of Disciplined firms, that follow a purely exploitative behavior and that of firms that of Opportunistic firms that, as the punctuated equilibrium idea suggests, cycle through periods of exploration and exploitation. We did so for four different combinations of strategic planning quality (HQSP and LQSP) and environmental complexity (high and low). This proved to be a relevant distinction, as results show that the relative performance of different strategies was contingent to the complexity of the environment and the quality of the strategy formulation.

Our results also have implications for the debate on planning *vs* emergence (Mintzberg, 1990; Ansoff, 1991). They suggest that in simple environments and even in complex environments when the competing firms have a thorough understanding of their strategic options, Porter's (1996) advice to strategic leaders to resist 'constant pressures to compromise, relax trade-offs and emulate rivals' (p. 77) is sound. Given a deep knowledge of their competitive arenas (in our study, 'performance landscapes') and the ability to easily evolve incrementally when complexity is low, Disciplined firms outpace rivals that engage in varying degrees of opportunistic behavior. These situations are consistent with the rational tradition of strategic planning embedded in the design, planning and positioning schools of strategy (Mintzberg *et al.*, 1998).

As the environment becomes more complex and firms lack a thorough understanding of their competitive landscape, however, this situation changes. The combination of complexity and low-quality strategic plans, usually associated with a turbulent environment where business models are not clearly defined, dramatically changes the outcome. Poor strategies coupled with difficulties to make progress based on local search due to high complexity make strategies based on a very disciplined execution of the initial strategic plan the worst possible option. Given the widespread agreement among academics and practitioners that business environments are becoming increasingly dynamic and complex (D'Aveni, 1994; Day and Reibstein, 1997; Brown and Eisenhardt, 1998; Normann, 2001), these conclusions are especially relevant, as the ability of firms to develop sound strategic plans in these kinds of environments is generally limited. In other words, managers' strategic decisions in an increasingly number of industries reflect what we labeled as Low Quality Strategic Planners in this paper.

This conclusion is consistent with Brews and Hunt's (1999) empirical finding that as environmental instability grows, so does planning flexibility. However, these results are not a case in favor of purely emergent approaches. We found that the Purely Explorative strategy created in our model as a control case does not become the top performer even in the cases of highest complexity. This posture can never overcome completely its initial lack of positioning intelligence. These results are consistent with Mintzberg *et al.*'s (1998) notion of Realized Strategy as a synthesis of an intended strategic direction and the flexibility to address relevant emergent aspects.

These insights also have important implications for organizational design. Our simulations show that the performance of a firm facing a complex environment and therefore having a highly interdependent architectural design, such as a highly interdependent CM-form or a matrix structure, is highly contingent on the quality of the Strategic Plan that frames the business decisions. While it is obviously non-trivial to distinguish *ex ante* in particular cases whether a company is a High or a Low Quality Strategic Planner, it is important to know that the more complex the organizational form, the more risky it will be to adhere rigidly to an established strategic plan. The complexity of highly interdependent structures makes incremental change more difficult, increasing the risk that the firm might suffer a 'complexity catastrophe' (Kauffman, 1993; Brown and Eisenhardt, 1998), that is, the inability to evolve successfully as a result of the constraints imposed by the suppressing effects of its highly interdependent design. If these firms chose to adopt an M-form, the quality of the strategic plan would be less critical for their performance, as the lower ruggedness of their landscape eases their adaptive evolution process. However, for a firm having related businesses and operating in a highly turbulent environment, adopting an M-form might lead to an 'error catastrophe' (Kauffman, 1993; Brown and Eisenhardt, 1998) or failure to address the degree of complexity of the environment. If a firm has a cluster of highly related and, therefore, highly interdependent businesses (as they demand close coordination for activity and knowledge sharing), it will need to find a balanced organizational design that addresses the needs of knowledge and activity sharing without provoking a complexity catastrophe. Thus, these findings give formal and more general support to insights provided by case study-based research that prescribes the superiority of emergent approaches for intrafirm efforts aimed at creating corporate advantage (Brown and Eisenhardt, 1998; Goold and Campbell, 1998; Galunic and Eisenhardt, 2001; Goold and Campbell, 2002; Helfat and Eisenhardt, 2004). Emergent 'self organized' interdivisional cooperation initiatives are, by definition, loosely coupled, that is, less demanding in terms of the interdependences they create across units.

By contrast, centrally imposed interdivisional collaboration initiatives tend to be formally structured, generating tight couplings affecting business units sometimes regardless of the real need for interdivisional collaboration (Goold and Campbell, 1998). These situations increase interdependences unnecessarily, with the proliferation of coordination meetings, *ad hoc* reporting requirements, etc. Self-organized, loosely coupled collaboration initiatives offer a hope for managers who struggle to navigate between the 'Scylla and Charibdes' resulting from either naively simple designs that fail to address environmental variety, or unnecessarily complex ones showing very high suppressing effects. An architectural design that relies more strongly on self-organized interdependence at the business unit level allows firms to 'economize' on organizational interdependencies while still achieving the potential for synergy development resulting from interdivisional activity sharing and knowledge transfer.

Notes

1 In the model, we assume that all business units have an equal weight on performance and that individual decisions made within each business unit also have an equal weight on performance.

2 It is worth mentioning that the majority rule does not imply a decision made by majority. The majority rule implies that business managers can choose strategies only if they satisfy the restriction imposed by the corporate level choice. If the corporate premise for such unit is 'one', the business unit only can choose strategies in which 'one' appears on the majority of its decisions. It is just one way to model the impact of corporate strategic plans on business decisions.

3 It should be clear that $T=4$ and 8 are discretionary choices to represent intermediary states. As T gets larger, we approach strategic planning, and as T approaches zero we obtain financial control.

4 The law of requisite variety holds that 'control can be obtained only if the variety of the controller … is at least as great as the variety of the situation to be controlled' (Beer, 1972, cited in Richardson, 1991). Or in Ashby's own picturesque phrasing, 'Only variety can destroy variety' (Ashby, 1956, cited in Richardson, 1991).

5 Following Simon's treatment of complex problems (Simon, 1996), we assumed that total decomposability is impossible within a single business unit, as the different activities within a single business, such as manufacturing, sales, *R&D*, are, by definition, interdependent. Therefore, we discarded cases with $K_W=0$, due to their lack of realism, and modeled only firms with $K_W=1$ and $K_W=2$ for each of the four different alternative levels of K_B discussed above.

6 A strategic change is said to suffer suppressing effects when there is a side effect or 'backfire' to that initiative that prevents it from achieving the intended effects. For instance, by increasing the length of production runs a firm may gain in manufacturing cost efficiency, yet sales may be lost as a result of the firm's reduced ability to respond quickly to changes in demand, thus offsetting the impact of increased operational efficiency on profits.

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Appendix 1

Computation of the performance associated to any strategy

The value of one attribute within each business unit depends on the value of the K_W successive elements of the string. Suppose that BU1's policy choices are represented by the vector $\{0, 1, 1\}$. If $K_W = 1$, this means that the performance value of the first attribute included in the string (in our case, policy decisions) depends on the value of the second element, the performance value of the second element depends on the value of the third, and the performance value of this depends on the value of the first element. This circular treatment of the vector when determining interdependencies between variables in order to compute performance values is taken from Kauffman (1993).

A random number, generated from a uniform distribution ranging from zero to one, is assigned to constitute the performance contribution of a zero in the first attribute when there is a one in the second element. A different random number is generated when there is a zero in the first element and a zero in the second element. Thus, each policy can take 2^{K_W+1} values, depending on the value of the policy itself (either zero or one) and the value of the K_W other attributes with which it interacts. The procedure is repeated for each attribute of the three divisions. In this way we obtain the performance value of each policy within each business unit, taking into account the impact of other variables within the same division.

In order to complete the computation of the performance contribution of each individual attribute, we must assess the impact of the interaction between business units on such performance. We assumed that every business unit has an impact on the others' performance value. This effect is operationalized by treating corporate decisions as variables (Gavetti, 2005). Each business unit can take only two possible values: zero or one. The overall corporate strategy is represented by the value of the policies corresponding to the three divisions, for example $\{1, 1, 0\}$. Then, a random number, generated from the uniform distribution ranging from 0 to 1 is assigned to represent the performance contribution of $D1$ in $U1$, when $U1$ takes a one, $U2$ takes a one and $U3$ a zero.

The global performance contribution of a given policy variable is calculated according to the following formula (Gavetti, 2005):

$$F_i = (1 - K_B) \times F_{Wi} + K_B \times F_{Bi},$$

where F_i is the global fitness contribution of variable i, F_{Wi} its contribution taking into account interdependencies within the division, and F_{Bi} the effect of interdependences between business units. The parameter K_B tunes the degree of decomposability between the decisions made by the different business units. K_B can take any value between zero and one. If $K_B = 0$, the contribution of every business unit to the firm's overall performance is independent of decisions made within other business units. In this case, we can say that there is full decomposability between decisions made by different business units. As the value of K_B increases, the decomposability of the firm's problems is reduced, because business units' contribution to performance is affected by other divisions' decisions. A particular firm's overall performance is equal to the average of the performance contributions of its N attributes, calculated as explained above.