AUTONOMOUS STRATEGIC BEHAVIOR, ORGANIZATIONAL LEARNING AND TOP MANAGEMENT SUPPORT: RE-EXAMINING FIELD RESEARCH WITH COMPUTATIONAL MODELING

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Abstract

Re-examining field research findings about three critical episodes in Intel Corporation's evolution we find that when autonomous strategic behavior significantly increased relevant organizational knowledge Intel top management provided sustained support; when it did not, top management support stopped. Deploying an extended version of March's (1991) computational model of organizational learning we find that, in stable and in moderately turbulent environments top management is likely to provide sustained support to autonomous strategic behavior only when it augments organizational knowledge that is significantly different from organizational learning already embodied in the firm's current corporate strategy. Top management support depends on detecting such change in organizational learning by increasing the rate of exploitation.

Keywords. Autonomous strategic behavior, organizational learning, top management support, field research, computational analysis, rate of exploitation, environmental dynamism.

1.0 Introduction

1.1 Autonomous strategic behavior and top management control

Field research of the process of internal corporate venturing in a large, science-based multi-business corporation (Burgelman, 1983a) highlighted the potential importance of the relatively little-noticed phenomenon of *autonomous strategic behavior*. Autonomous strategic behavior introduced new categories of product-market opportunity and related competences that were not part of the existing corporate strategy defined as "… the more or less explicit articulation of the firm's theory about its past concrete achievements" (Burgelman, 1983b: 66). This research extended Bower's (1970) multi-level process model of the resource allocation process in large complex organizations with the concept of *strategic context determination*. Strategic context determination, usually activated by entrepreneurial middle-level managers, is the part of the process that helped top management determine whether it made sense to amend the corporate strategy in support of autonomous strategic behavior. The strategic context determination process lets top management suspend (for some time) the selective effects of the structural context (which supports the existing corporate strategy) to assess the relevance of the new knowledge generated by autonomous strategic behavior. Kannan-Narasimhan and Lawrence (2018), for instance, identified steps that innovators used in reframing corporate resources to shape the strategic context for their autonomous strategic behavior before external market validation was available.

Research has illuminated how autonomous strategic behavior in various ways may inform top management in their decision-making about changing the corporate strategy (Bower and Gilbert, 2005; Burgelman, 2002; Burgelman et al., 2023; Kannan-Narasimhan and Lawrence, 2018; Mirabeau and Maguire, 2014; Pratap and Saha, 2018). Other lines of research also discovered that frontline managers frequently take initiative to pursue new ideas (Birkinshaw, 1997, Zimmerman et al., 2015) and sell strategic issues to their superiors

(Dutton and Ashford, 1994). These studies corroborate that bottom-up knowledge inflows provide higher level managers with an enhanced understanding of change regarding technologies, products and markets (Brady and Davies, 2004, Branzei et al., 2004) that may eventually lead to revising strategic decisions (Floyd and Lane, 2000; Ghoshal and Bartlett, 1994).

Why does autonomous strategic behavior emerge in the first place? Burgelman (1991) pointed out that the strategy-making process constitutes an opportunity structure within which individual participants seek to express their technical and social skills, and advance their careers. Some entrepreneurial employees may experience difficulties pursuing product-market opportunities associated with the existing strategy and may therefore be motivated to take the riskier road of pursuing product-market opportunities that potentially extend the existing corporate strategy; others may be encouraged by top management to do so. Employee recruitment practices that regularly seek to bring new technical and business-related talent into the organization—in part associated with employee turnover—may also be a source of autonomous strategic behavior. In light of this, autonomous strategic behavior as a non-directed organizational phenomenon emerges naturally, sometimes in the form of "bootlegging" (Criscuolo et al, 2014) or "skunk works" (Levinthal, 2021). Overall, autonomous strategic behavior may appear particularly attractive to employees in organizations where opportunities for "intrapreneurship" are readily available (Kacsperczyk, 2012)

Why does top management tolerate and/or encourage, and potentially support, autonomous strategic behavior? A long-standing research question in strategic management (e.g., Burgelman and Grove, 2007) and the theory of the firm (e.g., Rotemberg and Saloner, 2000) concerns identification of the conditions that motivate top management to support autonomous strategic behavior. This relates to important issues, such as whether all autonomous strategic behavior is actually good for the organization, and whether lack of top management support is always a bad thing. Autonomous strategic behavior, for instance, is sometimes viewed as a form of resistance to prevailing strategies imposed by top management (Dick and Collings, 2014; Laine and Vaara, 2007, Vaara and Lamberg, 2016).

Top management can encourage autonomous strategic behavior by making it relatively easy for middle managers to obtain resources to deploy in projects that do not flow from mandates from the top. Sull et al. (2015), for instance, find that more than 50% of middle managers are confident of securing significant resources that fall outside their strategic objectives, but also that they seldom take advantage of it. One important reason is that executives tend to look upon deviations from detailed roadmaps—specifying who should do what, by when, with what resources—as lack of discipline.

Top management also has a potentially important role in modulating autonomous strategic behavior through fostering the intrinsic motivation of organizational members (Simon, 1991). In high tech companies like *Google Inc.* for instance, technical personnel are encouraged to spend a certain proportion of time on idiosyncratic projects (Edelmann and Eisenmann, 2011). As Levinthal (2021: 76) observes, however, these initiatives "… are pursuing dimensions of progress that, while possibly not orthogonal to the organization's performance objectives, may not be highly collinear with them." Top management approve this arrangement because they are aware of its potential to protect and/or improve the fortunes of the company in highly dynamic competitive environments. Top management, however, also exercise authority by terminating some initiatives embodying autonomous behavior.

1.2 Top management support, organizational learning and computational modeling

Viewing the strategy-making process as a social learning process informed by autonomous strategic behavior Burgelman (1988) suggests a new research avenue for augmenting knowledge about what drives supporting or terminating top management decisions about autonomous strategic behavior. The intuition for this derives from a previously overlooked insight from a high-level executive in the original field study of internal corporate venturing (Burgelman and Sayles, 1986): "*New businesses have growth problems that top management does not easily understand. So, if you don't have a clear strategy, you only ask them what you know they will be able to understand. But, then you are always behind, and that will destroy your credibility.*" This insight implies that to get and retain top management support, autonomous strategic behavior must show that the knowledge it generates is relevant and different from the knowledge already encoded in the existing organizational learning. Such new knowledge increases top management's confidence in bringing the strategic context determination process for autonomous strategic behavior to a positive conclusion (or a negative one if it does not) and amending (or not) the existing corporate strategy.

To move this new research avenue forward, we combine two threads of study. First, we revisit field research about autonomous strategic behavior involved in several transformational and potentially transformational strategy-making events in Intel Corporation's evolution. Second, we juxtapose our qualitative insights about autonomous strategic behavior and organizational learning with computationally derived insights. To pursue these two study threads, we examine *how does the significance of changes in organizational knowledge associated with different instances of autonomous strategic behavior affect top management support*?

Our two research threads, in combination, link top management decisions about autonomous strategic behavior to March's (1991) theory of exploration/exploitation tradeoffs in organizational learning, which as Levinthal (2021) notes "… has become central in our thinking about the challenge of organizational learning and adaptation." We view autonomous strategic behavior as a specific type of *exploration*, and relate the concept of *organizational strategy* as defined above (the more or less explicit articulation of the firm's theory about its past concrete achievements) to March's concept of the *organizational code* comprising repositories of organizational learning (databases, rules, norms, forms, standard operating procedures, etc.).

We use modest modifications of March's (1991) computational model of exploration and exploitation to develop further insight into the role of *organizational learning* in gaining or failing to gain top management support for autonomous strategic behavior. We build on recent research using March's (1991) computational model which found that acquiring and assimilating heterogeneous new knowledge from outside the organization may drive exploration through autonomous strategic behavior (Chanda and McKelvey, 2020) because it has the potential to build new organizational learning distinct from that undergirding the existing organizational strategy.

1.3 Contributions

Our paper contributes to strategic management and organizational learning literatures in several ways. First, by adopting the perspective of organizational learning, a re-examination of previous field research findings provided new insight into top management support for, or termination of, autonomous strategic behavior related to three critical events of Intel Corporation's evolution. Second, findings produced with modest modifications of March's (1991) computational model of organizational learning help formulate three theoretical propositions about the relationship between top management support for autonomous strategic behavior and changes in organizational learning, and elucidate conditions of top management patience and environmental turbulence that may affect this relationship. Third, our findings indicate that activation of the strategic context determination process as a tool to increase the rate of exploitation may help top management assess more systematically the relevance of changes in organizational learning resulting from autonomous strategic behavior.

2.0 Field Research of Autonomous Strategic Behavior at Intel

2.1 Intel's strategic transformation

In the early-1980s, *Intel Corporation*, a market leader in the dynamic random-access memory (DRAM) industry, rapidly lost market share against Japanese competitors in the face of DRAM commoditization. Expertise in high-volume, high-quality silicon-based manufacturing had become the primary competency for competing in the rapidly commoditizing DRAM business, and Japanese companies dominated Intel and other US incumbents. Fortunately, Intel had already been pursuing in exploratory fashion—as an autonomous sideline business—the design of microprocessors as a new specialty product. In contrast to the commoditizing DRAM products, specialty microprocessor products called for competence in circuit design by LSI/VLSI technology (large-scale integration /very large-scale integration). Over time, middle managers allocated more and more resources to the specialty microprocessor products and away from commoditizing DRAM products. As IBM adopted Intel's microprocessors for its new PC product line, Intel management eventually realized that the company's future lay with microprocessors. Intel exited the memory business and focused resources on the microprocessor business. As a result, the relative importance of different distinctive competencies had changed. As Andy Grove put it (Burgelman, 2002: 117):

> *Intel had moved from a silicon-based distinctive competence in memory products to a distinctive competence in implementing design architectures in logic products*.

Having come to grips with this fundamental strategic change after several years of ambiguity, Chief Operating Officer Grove, in October 1985, told the remaining members of the old DRAM group: "*Welcome to the* [new] *mainstream of Intel*." The change also had big implications for Intel's incumbent senior managers. Grove quoted Chief Executive Officer Gordon Moore warning the top management group at the time of the DRAM exit and corporate transformation (Burgelman, 2002: 117):

> *You know, if we are really serious about this, half of our executive staff had better become software types in five years' time.*

In response to this warning, Grove reported that he started to visit software companies in order to re-educate himself (Burgelman, 2002: 117).

During an MBA class at Stanford Business School in the early 1990s, Grove pointed out additions to Intel's organizational knowledge (Burgelman, 2002: 137):

> *We learned that we had to get around the companies that had subjugated us in DRAM. We learned that high market share was critical for success, and that to get market share we had to be willing to invest in manufacturing capacity… We learned that commodity businesses are unattractive, so we didn't want to license out our intellectual property anymore.*

This story indicates that top management continued to support the autonomous strategic behavior of the microprocessor development team before actually changing the existing corporate strategy. They did so because it was developing novel organizational knowledge that departed significantly from the organizational learning associated with the existing semiconductor memory corporate strategy, and led to developing new products that turned out to be more viable in the rapidly changing external environment and more consistent with Intel's culture as a leading-edge differentiated high-technology company.

2.2 Intel's support and abandonment of RISC

A few years later, in the late-eighties, top management discovered that one of its engineers was leading an effort to develop an alternative microprocessor based on the RISC (reduced instruction set computing) standard. This standard was different from the CISC (complex instruction set computing) standard that Intel and its original equipment manufacturer (OEM) customers—Compaq, IBM, Olivetti, Samsung, Toshiba and others—were committed to. Yet, even though the OEM customers were apprehensive about Intel reducing support to CISC, Intel continued to fund the RISC efforts for a while and even came up with a RISC microprocessor (the i860). In a Stanford MBA class in February 1991, Andy Grove examined Intel's strategy-making process in light of how the company was dealing with RISC (Burgelman, 2002: 152-153). He said:

> *The strategic process reflects the company's culture. You can look at it positively or negatively. Positively, it looks like a Darwinian process: we let the best ideas win; we adapt by ruthlessly exiting businesses; we provide autonomy and top management is the referee who waits to see who wins and then re-articulates the strategy; we match evolving skills with evolving opportunities. Negatively it looks like we have no strategy; we have no staying power; we are reactive, try and move somewhere else if we fail; we lack focus…*

Eventually, Grove decided to disband the RISC team and continued on course with CISC (he had also learned that Motorola was experiencing a destructive internal competitive battle between RISC and CISC camps). In a later Stanford MBA class, Grove commented on the dangerous situation created by Intel's RISC processor (called the i860) for the company's existing strategic position (Burgelman, 2002: 153). He said:

> *It was a confusing period for Intel … The i860 was a very successful renegade product that could have destroyed the virtuous circle enjoyed by the Intel Architecture… Intel was helping RISC by legitimizing it … We were dabbling in it, and were trying to be the best of the second best.*

For Grove, a key lesson was that "not all paradigm shifts are paradigm shifts." Having concluded that RISC did not constitute a paradigm shift strengthened his determination to exploit fully Intel's favorable strategic position. He said (Burgelman, 2002: 153):

> *The commitment to the x86 architecture vectorized everybody at Intel in the same direction.*

Nevertheless, the autonomous experimentation produced some strategically important organizational learning related to the efforts of the RISC team to get applications developed for their new processor. Intel's Chief Marketing Officer recalled in 1999 (Burgelman 2002: 223):

> *With the Pentium [CISC] processor coming about, most of the software had been optimized for the 486 microprocessor, and we needed to get the ISVs [independent software venders] to move faster to develop software optimized for the Pentium. We realized we had this valuable resource in the RISC group, so we*

reallocated these people to recruit ISVs (...) From the work they did with the RISC processor, they developed a framework for working with ISVs, and this became a crucial capability for the core business.

This story indicates that the autonomous strategic behavior of the RISC team involved knowledge *close* to that associated with the company's current corporate strategy. Intel's top management was familiar with the RISC architecture and able to determine the advantages and disadvantages of RISC versus CISC. Having concluded that RISC would be somewhat better on some dimensions, but not by a sufficiently large measure to make OEM customers switch, top management abandoned support for the RISC processor, while nevertheless remaining alert to what had been learned about ecosystem development (relations with ISVs) that could support further exploitation in the core CISC business. By vectoring everybody at Intel in the same direction, however, Andy Grove strongly reinforced exploitation during the remainder of this tenure as CEO, at the expense of further sustained support for autonomous strategic behavior initiatives.

2.3 Intel's failure to exploit the networking business opportunity

In the early 1990s Intel revenues were about $6 billion and CEO Andy Grove charged a highly regarded senior executive with developing new business revenues for about $1 billion. By the mid-1990s, however, Intel core business revenues had grown to about $20 billion. Because of the continued rapid growth of the core microprocessor business, Grove began to view the efforts for developing new businesses (called Job 2) as a distraction. He felt, in particular, that the senior executive in charge focused too much on the success of the new Networking business (already roughly $300-400 million in revenues) and not enough on that of the core business (Job 1). Referring to his interaction with Grove, the senior executive recalled (Burgelman, 2002: 286):

"*Once he told me *that even if you get networking to $1 billion in revenue with normal 10 percent profits, then that would equate to $25 million a quarter, and I am making $1 billion a quarter profit on Intel Architecture.*'"

Asked why he did not support the new business initiative, Grove explained that this executive was not able to convince him of the importance of the networking business for Intel in senior management committee meetings, which served to determine (or not) the strategic context for new business initiatives. He said (Burgelman 2002: 281):

> "*I am not happy with statements that are somewhat right, but mostly wrong. Maybe I am too good for my own good. I weed out all the weeds, but also some of the potential seeds…*"

The senior executive originally in charge of networking observed that his successor was able to tie the networking business to the microprocessor strategy. He said (Burgelman, 2002: 279):

> *"[X] clearly got Networking better connected with Intel. He came up with the fast Ethernet 'big pipes for big processors' notion and building remote management hooks into the network cards."*

He also said that Craig Barrett, Grove's successor as CEO, became supportive enough to go to the board with a proposal to buy an established networking company after he had left Intel.

This story shows that the relevance of the new knowledge derived from autonomous strategic behavior associated with the networking business was initially too ambiguous to convince the CEO that it should receive full corporate support. The senior executive in charge was not able to overcome Grove's ambivalence, and was unable to activate the strategic context determination process for networking and make progress toward top management amending the corporate strategy. This confirms the importance of the previously mentioned insight that "new businesses have growth problems that top management does not easily understand, and that if you don't have a clear strategy you can only ask them what you know they will be able to understand, but then you are always behind and that will destroy your credibility". The successor senior executive was able to do so, but it turned out to be too late relative to the fast development of the networking industry and Cisco's extremely fast growth.

3.0 Computational Modeling of Autonomous Strategic Behavior

Analysis based on computational modeling serves to develop novel theoretical insights (Adner et al., 2009; Burton, 2003; Davis et al., 2007; Harrison et al., 2007; Levinthal, 2021). To that end, we deploy in this paper March's (1991) computational model to gain further insight into the relationship between autonomous strategic behavior, organizational learning and top management support, following the conceptual replication elaborated in Chanda and Miller (2019). As noted above, we view autonomous strategic behavior as a specific type of exploration and the knowledge embodied in the organizational code as a reasonable proxy for corporate strategy.

3.1 Organizational knowledge, organizational member knowledge and exploration through autonomous strategic behavior

Organizational knowledge comprises information stored in databases, user manuals, rules, forms, standard operating procedures, past and current strategic plans, etc. It is stored in the organizational code. *Organizational member knowledge*[1] comprises the latent knowledge held by the members of an organization (Hargaddon and Fanelli, 2002; Chanda et al., 2018). Referring to stocks of knowledge held by members of an organization, Hargaddon and Fanelli (2002: 294) clarify that "…the schemata—comprising scripts, goals, and identities—of members of an organization make up the latent knowledge available within that organization".

The stock of organizational knowledge augments upon drawing from the stock of knowledge of members. Conversely, learning from the organizational code alters the stock of knowledge of members. When top management permits exploration through autonomous strategic behavior, members obtain knowledge from outside the organization. This creates an additional flow of heterogeneous knowledge into the stock of knowledge of members.[2]

[1] *Organizational member knowledge* is alternately referred to as *collective human capital* by some authors, e.g., Chanda et al., (2018), von Nordenflycht, (2011), etc.
[2] Readers may refer to the *Appendix* for a detailed exposition of the mechanics involving the stocks and flows in March's computational simulation model that we deploy to derive our theoretical propositions.

Exploration through autonomous strategic behavior may involve organizational member knowledge that is similar to the organizational knowledge involved in the existing corporate strategy (organizational code); or it may involve organizational member knowledge that is substantially different. Joint consideration of stocks and flows is necessary to develop adequate theory regarding phenomena (Dierickx and Cool, 1989). This suggests that a difference in the initial stock of organizational member knowledge may lead to distinctive and interesting outcomes when an important flow— the rate of members learning from the organizational code (i.e., *the rate of exploitation* as we elaborate below)—is varied. This, in turn, may have bearing on sustained support or abandonment of exploration through autonomous strategic behavior.

In the computational simulation experiments that follow subsequently, we examine the likelihood of top management supporting exploration through autonomous strategic behavior that initiates with organizational member knowledge that is close to the organizational knowledge associated with the existing corporate strategy. We also examine the likelihood of top management supporting exploration through autonomous strategic behavior initiated with organizational member knowledge substantially different from the organizational knowledge underlying a firm's current corporate strategy. In both cases, and under varying conditions of environmental turbulence, we examine top management's use of changing the *rate of exploitation* to assess changes in new organizational knowledge as the key determinant of their support decisions.

3.2 Varying the rate of exploitation and managerial control

Exploitation takes place when employees consult repositories of organizational knowledge—such as databases, user manuals, rules, forms, procedures, and other organizational historical information—in order to devise process improvements (March, 1991). Top management can augment the rate of exploitation in a number of ways; for instance, by reducing the extent of tasks organizational members are required to carry out for day-to-day functioning, inviting suggestions from employees for process improvements, by creating dedicated teams tasked with improving organizational processes, and so on (Chanda and McKelvey, 2020).

Increasing the rate of exploitation related to exploration through autonomous strategic behavior enhances the use of existing organizational knowledge to assimilate heterogeneous new member knowledge in a bid to fashion potentially significant strategic change. Top management increasing the rate of exploitation and checking for enhancement of new organizational knowledge appears crucial in shaping the process of strategic context determination for autonomous strategic behavior (Burgelman, 1983a). Increasing the rate of exploitation gives an initiative embodying autonomous strategic behavior the impetus to move from inchoate, so far ill-understood (by top management) initiatives and serves as a stepping stone for top management to determine whether they correspond to truly new categories of corporate strategy (Burgelman, 1988).

In light of this, top management can use the rate of exploitation as a lever of control to assess change in the extent of new organizational knowledge created by a team engaging in an initiative embodying autonomous strategic behavior. Top management will be comfortable to let an existing organizational arrangement (involving conferment of autonomy) continue, if they are able to detect significant extent of change in organizational knowledge levels upon changing the rate of exploitation.

In what follows, we use an extended version of March's (1991) computational model to further examine the novel insights gained from applying the lens of organizational learning to previous field research findings reported above. In particular, we intend to examine the extent to which top management can use the rate of exploitation as a *lever of control* to observe changes in organizational knowledge associated with exploration through autonomous strategic behavior.

4.0 Computational Model Specifications

We introduce two relatively modest modifications of March's model. First, we allow the initial endowment of organizational member knowledge to vary, whereas March (1991) used the same value for the initial endowment of organizational member knowledge in all his experiments. Second, we use a somewhat lower value for the rate of infusion of heterogeneous new knowledge to model exploration through autonomous strategic behavior. We explain and justify these extensions below.

4.1 The environment and the organization

In the model, the environment or the external reality (**R**) pertaining to an initiative embodying exploration through autonomous strategic behavior is an *M*-bit string. Each bit or dimension of **R** can take value of either "-1" or "+1".[3] At the beginning of any simulation experiment, **R** is populated such that "+1" or "-1" occurs with probability of 0.50.

The *commandeered section of the official organizational code* (**CSOC**) where the team carrying out autonomous strategic behavior keep their databases, rules, forms, norms, operating procedures, etc., is also an *M*-bit string. At the beginning of simulation all bits (or dimensions) of the **CSOC** are populated with value "0", signifying "no opinion". We use the term CSOC instead of "organizational code" to indicate that this is a separate placeholder where members engaging in exploration through autonomous strategic behavior develop organizational knowledge that is somewhat distinct from and independent of the organizational knowledge deployed in the current strategy of the company.[4]

The 'organization' for studying exploration through autonomous strategic behavior comprises *N* members. An *M*-bit string represents each member. To provide members with knowledge close to that associated with a company's current corporate strategy, the member

[3] In place of "+1" and "-1", we could use the labels "A" and "B" with no loss of generality.
[4] We thank an anonymous reviewer for drawing our attention towards clarifying this nuance.

bits (or belief dimensions) are populated by drawing values form the set {-1, 0, +1} where each value has one-third probability of materializing. March (1991) also used this mechanism for populating the initial belief dimensions of organizational members. Hence, we refer to such organizational populations as *Marchian populations*. In order to construct an organizational population with initial *organizational member knowledge* substantially different from (i.e., non-aligned with) the organizational knowledge associated with the current corporate strategy, we first create a *Marchian population*. Thereafter, following the specifications provided by Chanda et al., (2018), we overwrite a certain fraction (*v_def*) of the organizational member belief dimensions with values that are opposite to those in the corresponding bits in the reality string **R**. We designate the resultant population as a *sub-Marchian population*. In the simulation experiments, we overwrite 15% of members' bits of a *Marchian* population to obtain a *sub-Marchian* population (i.e., we use *v_def* = 0.15). Thereby, the ratio of incorrect/correct initial beliefs of members increases from 1:1 to 1.5:1. We cite a *sub-Marchian* population as having initial *organizational member knowledge* substantially different from (or non-aligned with) the knowledge associated with the current corporate strategy on account of the higher proportion of incorrect beliefs, compared to that in the knowledge of *Marchian* population.

4.2 Learning by the CSOC (commandeered section of the official organizational code)

The **CSOC** accumulates knowledge by learning from knowledgeable members at a rate given by a parameter p_2. The **CSOC** has the ability to identify members having superior knowledge about the external reality **R**. In each period, the **CSOC** identifies the set of such *members carrying superior knowledge* (MCSK hereafter). For every bit position, the **CSOC** takes a poll among the MCSK, to determine how many recommend the value to be "+1" and how many recommend the value to be "-1". If more MCSK recommend a non-zero value that is different from the value present in the **CSOC**, the probability that the **CSOC** value remains unchanged is given by $(1 - \boldsymbol{p_2})^k$, where k (> 0) is the difference between the number of members who recommend a change, and the number of members who do not recommend a change. The MCSK who have "0" value for a given bit position do not contribute to the decision-making, for that particular bit position. In the computer program, learning by the **CSOC** takes place based on the values of members' beliefs in the immediate prior period. It follows that knowledge values in the **CSOC** start undergoing change from the second period onwards.

4.3 Learning by the members of the organization

In each time step, members learn from the instance of the **CSOC** that existed at the immediate prior period. For each bit position in the belief string of a member, the corresponding value in the **CSOC** is read. If the **CSOC** has a non-zero value that is different from the value in the member's belief string, the member updates his/her value to the value from the **CSOC** with a probability $\boldsymbol{p_1}$. The parameter $\boldsymbol{p_1}$ represents the rate of member learning. A faster rate of learning implies a greater rate of reduction of diversity of the knowledge of organizational members. Reduction of diversity is a hallmark of exploitation. Accordingly, we denote an organization as carrying out exploitation at a high rate when $\boldsymbol{p_1}$ is set to a value 0.90. Otherwise, when $\boldsymbol{p_1}$ is set to a value of 0.10, we denote the organization as carrying out exploitation at a low rate.

We note that March (1991) does not explicitly equate the member learning rate ($\boldsymbol{p_1}$) to exploitation because he elaborates on two distinct conceptions of exploration-exploitation—as ends of a *continuum* (Figure 2, p. 77) and as *orthogonal* constructs (Figure 4, p. 79) [please also see Chanda and McKelvey, 2020]. In the continuum conception of exploration and exploitation—roughly corresponding to the *structural context* of the Bower-Burgelman model— exploration is fashioned by having a higher proportion of slow learners, and therefore slower erosion of heterogeneity of knowledge (*internal to the firm*) of members.

Having a higher proportion of fast learners (and hence faster erosion of knowledge diversity) fashions exploitation. In the orthogonal conception of exploration and exploitation—roughly corresponding to the *strategic context* in the Bower-Burgelman process model—the member learning rate (***p*1**) connotes assimilation of knowledge of members (again, leading to lowering of knowledge diversity) and exploration through autonomous strategic behavior takes place by importing heterogeneous knowledge *from outside the organization*. The scope of our research here is limited to the strategic context.[5]

Our mapping the ***p*1** variable to exploitation responds to the following passages in March (1991). First, "slow learning … leads to inadequate exploitation" (p. 78-79), implicitly suggesting that learning rate maps to exploitation. Second, March mentions "… the learning dominance of exploitation" (p. 85). Third, we interpret that reduction of diversity is a hallmark for exploitation from March's statement that "Slow learning on the part of individuals maintains diversity longer, thereby providing … exploration" (p. 76).

4.4 Exploration through autonomous strategic behavior

In situations involving *exploration through autonomous strategic behavior*, we use an additional parameter, $\boldsymbol{p_5}$, for which a non-zero value (say ten percent) signifies the proportion of belief dimensions of a subset of organizational members that are randomized as a result of acquiring heterogeneous new knowledge from outside the organization. Randomization of a belief bit is carried out by assigning a value from the set {-1, 0, +1} with each element having a one-third chance of materializing. To implement absence of exploration through autonomous experimentation we set $\boldsymbol{p_5}$ to a value of zero.

In our study, one-fourth of organizational members potentially engage in exploration through autonomous experimentation by obtaining heterogeneous new knowledge for ten percent of their belief dimensions, in any given time-step. In March (1991), in contrast, the

[5] We thank an anonymous reviewer for the suggestion regarding providing this clarity.

rate of infusion of heterogeneous new knowledge is fourfold the rate we use. This so because in March's model an analogous construct for importing heterogeneous knowledge from outside the organization, turnover*,* (implemented by replacement of an entire belief string of a member with a randomly generated belief string) was defined such that, in every time step, 10% of the organizational members have 100% of their belief bits randomized. The ten percent rate of heterogeneity infusion used in March's experiments constitutes a high rate, entailing that 100% of organizational members get all their extant knowledge replaced in a matter of ten time-steps (which could be ten weeks, or ten months or ten quarters). In order to motivate a lower (more plausible) rate of inflow of heterogeneity from outside the organization, we allow that, in a given time step, one-fourth of the organizational members involved in exploration through autonomous strategic behavior have about ten percent of their belief-bits randomized.

We note that the process of obtaining heterogeneous knowledge from outside the organization ($\boldsymbol{p_5}$ process) involves erosion of the knowledge of the concerned member, since, following March (1991), we model replacement of belief-values by random values (and not *net* addition of new dimensions of knowledge). The impact of this erosion of knowledge—in some beliefs of some members—may not be harmful if, prior to the intervention from the $\boldsymbol{p_5}$ process, the organizational code (specifically, the CSOC) already captured that knowledge.

Moreover, in subsequent ($\boldsymbol{p_1}$) learning cycles the concerned member has a chance to re-incorporate the knowledge by learning from the CSOC. The impact of the $\boldsymbol{p_5}$ intervention is significant in a positive sense if a new value matches with the external reality whereas the CSOC value—as well as the value in majority of other org members—is incorrect. In such case, in a subsequent period, the member undergoing $\boldsymbol{p_5}$ process is likely to be 'elevated' to the group of knowledgeable members who advise the CSOC, since he/she now has higher knowledge (and the CSOC learns from knowledgeable members who know more about the external reality than itself).

In contrast, the risk of an incorrect knowledge value obtained by the $\boldsymbol{p_5}$ process infiltrating into the CSOC is substantially lower. When the member undergoing $\boldsymbol{p_5}$ process has lower knowledge, the probability of being elevated to the "knowledgeable" group that advises the CSOC is lower.[6]

4.5 Model parameters

A given simulation experiment is repeated ten thousand times, with distinct draws for stochastically varying parameters ($\boldsymbol{p_1}$, $\boldsymbol{p_2}$, $\boldsymbol{p_4}$, $\boldsymbol{p_5}$). Results reported are averages over ten thousand distinct runs. Also, in each iteration the values in the reality string **R** and the values in the knowledge strings of organizational members are regenerated by means of random draws. In the Table **1** below, we report the parameter values used in experiments in the third column. These values are similar to those used in March (1991). We carried out robustness checks with some neighboring values for each parameter and found that the qualitative results are the same as reported in this study.

>>>>>>>>>>>>> Insert **Table 1** about here <<<<<<<<<<<<<<<<

5.0 Computational Results

We first present results (Figure **1**) for organizations endowed with a moderate level of initial organizational member knowledge— *Marchian* populations. Here, at the beginning of the simulation experiments, organizational member knowledge is close to the knowledge involved in a firm's current corporate strategy. Thereafter we present results (Figure **2**) for organizations having member knowledge substantially non-aligned to the firm's current corporate strategy at the beginning, i.e., *sub-Marchian* populations. Next, we present results

[6] We thank an anonymous reviewer for suggesting that we provide this clarification.

pertaining to a *dynamic* environment (Figure **3** and Figure **4**), characterized by continuous, unpredictable change. In all our figures, "organizational knowledge" refers to the stock of knowledge accumulated in the *commandeered section of the official organizational code* (CSOC) where the team engaging in autonomous strategic behavior store the new knowledge (plans, designs, databases, operating instructions etc.) they created.

In all the graphical results, on the horizontal axis, we show the passage of time, as *Time period* (*T*). On the vertical axis, we show the absolute difference of outcomes of low and high exploitation. As stated earlier, we set $\boldsymbol{p_1}$ = 0.10 to connote a low rate of exploitation and we set $\boldsymbol{p_1}$ = 0.90 to connote a high rate of exploitation. Thus, for each experimental data point, we first obtain the level of organizational knowledge developed in the CSOC, for low rate of exploitation and for high rate of exploitation, as the organizational outcome. Thereafter, we show the absolute difference of these two values on the vertical axis.

Moreover, we set up an *interpretation criterion* for the graphical results: if the value on the vertical axis is less than ten percent, we shall deem that top management is unable to discern substantive change in new organizational knowledge by varying the rate of exploitation. This may engender a feeling of *not* being in control, thereby jeopardizing the continued support for the project. Further, if the value in the vertical axis is greater than ten percent, we deem that the top management can readily discern substantive change in new organizational knowledge upon operating the lever comprising varying the rate of exploitation. Thereby top management have a sense of being in control, which in turn may head-off a decision to shut down the project or initiative under review.[7]

5.1 Exploration through autonomous strategic behavior involving initial organizational member knowledge close to that associated with the current strategy

[7] We thank an anonymous reviewer for suggesting this clarification.

In Figure **1** we plot the absolute difference in organizational knowledge obtained by low vs. high rate of exploitation over time, under conditions of initial organizational member knowledge being closely aligned with knowledge associated with a firm's current strategy (*Marchian* populations). The dark-colored bars represent situations where top management permits obtaining heterogeneous knowledge from outside the organization ($\boldsymbol{p}_5 = 0.10$), i.e., conditions of exploration through autonomous strategic behavior. The light-colored bars represent situations where there is no inflow of heterogeneous knowledge from outside the organization ($\boldsymbol{p}_5 = 0$).

>>>>>>>> Insert **Figure 1** about here <<<<<<<<

Our experimental results demonstrate that:

(I) If members are permitted to carry out exploration through autonomous strategic behavior ($\boldsymbol{p}_5 = 0.10$), the absolute difference in outcomes

[Organizational knowledge obtained by exploiting at a low rate ($\boldsymbol{p}_1 = 0.10$) – Organizational knowledge obtained by exploiting at a high rate ($\boldsymbol{p}_1 = 0.90$)]

(dark-colored bars) is negligible (say, less than ten percent). In this case, we posit that top management is unable to observe change in organizational knowledge upon changing the rate of exploitation. Hence, top management is likely to be uncomfortable with this option.

(II) If exploration through autonomous strategic behavior associated with obtaining heterogeneous knowledge from outside the organization is forbidden ($\boldsymbol{p}_5 = 0$) the absolute difference in outcomes

[Organizational knowledge obtained by exploiting at a low rate ($\boldsymbol{p}_1 = 0.10$) – Organizational knowledge obtained by exploiting at a high rate ($\boldsymbol{p}_1 = 0.90$)]

(light-colored bars) is sizeable (say, greater than ten percent for $T \geq 30$). This enables top management to observe change in organizational knowledge upon changing the rate of exploitation. Top management is likely to prefer this option.

Thus, we have:

Proposition 1. Exploration through autonomous strategic behavior that involves initial organizational member knowledge that is close to the knowledge associated with the firm's current strategy is unlikely to obtain support from top management.

5.2 Exploration through autonomous strategic behavior involving initial organizational member knowledge that is substantially different from (or non-aligned to) the knowledge associated with the current strategy

In Figure **2** we plot the absolute difference in organizational knowledge obtained by low vs. high rate of exploitation over time, where the initial organizational member knowledge is substantially different from (i.e., non-aligned to) the knowledge associated with a firm's current corporate strategy (*sub-Marchian* populations).

>>>>>>>> Insert **Figure 2** about here <<<<<<<<

The light-colored bars—representing the absolute difference between the outcomes of low and high exploitation when exploration through autonomous strategic behavior associated with heterogeneous outside knowledge is disfavored ($\boldsymbol{p_5} = 0$)—attain very small values (all less than ten percent). Thus, top management will be unable to detect a change in organizational knowledge upon changing the rate of exploitation. Hence, they are unlikely to prefer this option.

The distribution of the dark-colored bars—embodying conditions where exploration through autonomous strategic behavior associated with heterogeneous outside knowledge is permitted ($\boldsymbol{p_5} = 0.10$)—informs that when the duration (T) of the project is thirty periods or more ($T \geq 30$) the difference in outcomes from low and high exploitation is substantial (ten percent or higher). In this case, top management can readily observe change in organizational outcomes upon changing the rate of exploitation. Thus, if top management assesses exploration through autonomous strategic behavior after a lapse of time from its starting (thirty periods or more), they are unlikely to terminate it. This is a somewhat unexpected, but potentially important, finding of our computational analysis.

Proposition 2. Exploration through autonomous strategic behavior involving initial organizational member knowledge that is substantially different from the knowledge associated with the firm's current strategy is likely to obtain sustained support from top management, but only if top management extends a certain extent of strategic patience (i.e., provides some time before undertaking the evaluation of a fledgling initiative).

5.3 Exploration through autonomous strategic behavior in turbulent environments

Computational analysis facilitates examining systematically the effects of different conditions of environmental turbulence on the relationship between exploration through autonomous strategic behavior, organizational knowledge and top management support.

The results discussed above pertain to situations where the environment is relatively stable. To simulate *turbulent* environments, following March (1991), we model an environment characterized by continuous and unpredictable change by allowing the dimensions of reality to change value with a certain probability ($\boldsymbol{p_4}$) in any given time-step. We vary $\boldsymbol{p_4}$ in the range $0.0025 \leq \boldsymbol{p_4} \leq 0.02$ to model turbulence from low to high levels. For example, the upper value of 0.02 for $\boldsymbol{p_4}$ means that the entire reality (**R**) changes *twice* in a matter of 100 time-steps, which could be 100 weeks (~2 years) or 100 months (~8 years) or 100 quarters (~25 years). However, we hardly expect the reality (**R**) to change by more than 50% to 75% in such time span.

>>>>>>>> Insert **Figure 3A** and **Figure 3B** about here <<<<<<<<

Figure **3A** shows the absolute difference of organizational knowledge outcomes between low and high exploitation ($\boldsymbol{p_1} = 0.10$ and $\boldsymbol{p_1} = 0.90$ respectively), under varying levels of environmental turbulence, with initial organizational member knowledge close to the knowledge associated with the firm's current strategy, where exploration through autonomous strategic behavior associated with heterogeneous outside knowledge is *not* permitted ($\boldsymbol{p_5} = 0$). We observe that the difference of outcomes is above the ten percent mark for $T \geq 30$ for the levels of environmental turbulence likely encountered in the real world ($0.0025 \leq \boldsymbol{p_4} \leq 0.0075$). This suggests that top management will be comfortable with the arrangements, since it is feasible to observe change in organizational knowledge upon changing the rate of exploitation.

Figure **3B** shows the absolute difference of organizational knowledge outcomes between low and high exploitation ($\boldsymbol{p_1}$ = 0.10 and $\boldsymbol{p_1}$ = 0.90, respectively), under varying levels of environmental turbulence, with the initial organizational member knowledge close to the organizational knowledge associated with the firm's current strategy, where exploration through autonomous strategic behavior associated with heterogeneous outside knowledge is permitted ($\boldsymbol{p_5}$ = 0.10). We observe that the difference of outcomes is well below the ten percent mark at all times. Thus, top management will not be in a position to observe change in organizational knowledge upon changing the rate of exploitation. Hence, top management is unlikely to feel comfortable with the arrangements, and will, quite likely, not support exploration through autonomous strategic behavior associated with heterogeneous external knowledge. Thus, **Proposition 1** is valid in a turbulent environment as well: top management is unlikely to support exploration through autonomous strategic behavior associated with initial organizational member knowledge that is close to the knowledge associated with the firm's current strategy. This computational finding extends the insights derived from our re-examination of field research findings.

>>>>>>>> Insert **Figure 4A** and **Figure 4B** about here <<<<<<<<

Figure **4A** shows the absolute difference of outcomes between low and high exploitation ($\boldsymbol{p_1}$ = 0.10 and $\boldsymbol{p_1}$ = 0.90, respectively), with the initial organizational member knowledge substantially non-aligned to the knowledge associated with the current strategy (*sub-Marchian* populations), *absent* exploration through autonomous strategic behavior associated with heterogeneous outside knowledge ($\boldsymbol{p_5}$ = 0), and under varying levels of environmental turbulence. We observe that the difference of outcomes is always less than ten percent. This suggests that top management would be open to alternative arrangements, viz.

arrangements that allow observing change in organizational knowledge upon changing the rate of exploitation.

Figure **4B** shows the results for the situation when exploration through autonomous strategic behavior *is allowed* ($\boldsymbol{p_5}$ = 0.10). We observe that for low to moderate levels of environmental turbulence ($\boldsymbol{p_4}$ = 0.0025, $\boldsymbol{p_4}$ = 0.005, $\boldsymbol{p_4}$ = 0.0075), the difference between outcomes of high and low exploitation goes past the ten percent mark around period 28 to 42. The difference remains above ten percent, thereafter. In these instances, top management can readily observe change in organizational outcomes upon changing the rate of exploitation. Hence, it is quite likely that top management will support exploration through autonomous strategic behavior. It will have a chance of materialization provided top management gives it a bit of time initially, i.e., invokes strategic patience. Thus, Proposition **2** applies in an environment characterized by low to moderate turbulence as well. This computational finding also extends the insights derived from our re-examination of field research findings.

We further observe, however, that for very high levels of turbulence ($\boldsymbol{p_4}$ = 0.01, $\boldsymbol{p_4}$ = 0.02) the benchmark of ten percent difference between high and low rates of exploitation is unattainable. Thus, under conditions of extreme turbulence, top management will be deprived of the wherewithal (varying the rate of exploitation) to assess effectiveness of exploration through autonomous strategic behavior. At the limit, this extreme situation corresponds to r*unaway industry change* (Burgelman and Grove, 2007). In this situation, top management is unlikely to be able to support simultaneously both exploiting existing organizational knowledge and developing new knowledge by exploration through autonomous strategic behavior. While a degree of indeterminacy remains, on balance it seems that top management is more likely than not to refrain from sustaining exploration through autonomous strategic behavior. This computational finding further extends the insights derived from our re-examination of field research findings. Thus, we have:

Proposition 3. Exploration through autonomous strategic behavior is highly unlikely to obtain support from top management under conditions of high levels of environmental turbulence.

>>>>>>>>>>>>>> Insert **Figure 5** about here <<<<<<<<<<<<<<<<

Table **2** provides a summary of the research findings. Figure **5** recapitulates our propositions in the form of a schematic diagram. The right-most branch depicts that exploration through autonomous strategic behavior is highly unlikely to obtain top management support if environmental turbulence is very high (Proposition **3**). The left-most branch depicts that in stable and moderately turbulent environments, exploration through autonomous strategic behavior involving initial organizational member knowledge substantially different from that associated with the firm's current corporate strategy is quite likely to get top management support (Proposition **2**). The middle branch depicts that in stable and moderately turbulent environments, exploration through autonomous strategic behavior involving initial organizational member knowledge close to that associated with a firm's current corporate strategy is less likely to get top management support (Proposition **1**).

5.4 Limitations

First, we make several simplifying assumptions. We assume that the organizational code has the ability to identify members who are more knowledgeable about reality than the code itself – the members carrying superior knowledge (MCSK). In practice, organizations may make mistakes in identifying the MCSK (Chanda and Ray, 2015). We also assume that the organizational code follows a principle of simple majority among the MCSK to determine the recommendation for updating a knowledge dimension. In practice, a vocal and influential minority may dominate a decision process (Chanda and Ray, 2015; Chanda, 2017). We furthermore assume environmental turbulence characterized by unpredictable, continuous change. Alternate conceptualizations are of course possible as well. Finally, related to resource constraints we assume that the total number of organizational members is constant.

In reality, resource constraints may become more acute as levels of exploitation or exploration go up.

Second, while we determine the merit of exploration through autonomous strategic behavior in terms of developing a discernible change in organizational knowledge, enhancement of organizational knowledge may not always translate into higher organizational performance. An organization's fortunes in a competitive milieu will be heavily dependent on its ability to put the knowledge to suitable use to improve performance as well as the ability of its competitors to do so.

Third, to make the association between top management's sustained support and discernible change in the extent of new organizational knowledge, we assume that top management is neutral provided they have a sense of being in control. That is, they accept the potential importance of creating new knowledge in the organization, and want do the right things even when criteria are non-existent or ill formed. We suggest that discerning new organizational knowledge creation could be a criterion for GO/NO-GO judgments by top management for projects involving autonomous strategic behavior.[8]

We find that top management might choose not to terminate support upon seeing significant increase in new organizational knowledge. Here, varying the rate of exploitation looking for significant increase in new organizational knowledge acts like a dipstick, based on (readings of) which top management could consider withdrawing/ not withdrawing support. In contrast, autonomous strategic behavior does not have a future if top management prefers the status quo, and the creation of new knowledge in the organization is discouraged.[9]

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[8] In a context such as *internal corporate venturing*—where top management has more skin in the game—it is quite likely that top management will choose to stay on course, unless funding runs out before any discernible breakthrough, OR a competitor beats them in a 'winner-takes-all' race, i.e., additional criteria could be in play.
[9] Companies that have minimal extent of internal knowledge creation mostly choose to buy or license technology—or acquire a whole company having a sought-after technology (if they have the clout and wish to deter competitors from getting hold of that technology). We thank an anonymous reviewer for drawing our attention to this possibility.

Acknowledging these limitations, however, enables us to stay close to March's (1991) model, and leverage its long heritage in management and organization studies. We hope that other scholars may take further steps in relaxing these limitations.

6.0 Discussion

Re-examination of one successful transformational event and two unsuccessful ones of Intel Corporation's strategic evolution revealed that support (first event), termination (second event), and lack of timely support (third event) for associated autonomous strategic behavior depended on convincing top management that it developed relevant organizational knowledge that was different from the organizational learning already encoded in the existing corporate strategy. These novel insights suggested a connection to March's (1991) theory about exploration and exploitation in organizational learning. In light of this, we viewed autonomous strategic behavior as a specific type of exploration and related organizational strategy to March's concept of organizational code; and viewed top management increasing exploitation to support (or not) autonomous strategic behavior in relation to activation (or not) of the strategic context determination process.

Results from deploying an extended version of March's (1991) computational model confirmed that sustained top management support for exploration through autonomous strategic behavior materializes when it involved initial member knowledge significantly different from the knowledge embodied in the firm's current strategy (Proposition **2**). In contrast, top management terminated support when the initial member knowledge was similar to that in a firm's current strategy (Proposition **1**). These results held in stable as well as in moderately turbulent environments. In contrast, top management support was unlikely in highly turbulent environments (Proposition **3**).

Computational results also indicated that top management increasing the rate of exploitation revealed relevant differences in organizational knowledge, and determined whether they constituted truly new potential categories of corporate strategy. This suggested that increasing the rate of exploitation is a potentially useful informative tool for top management as they consider support for (or termination of) exploration through autonomous strategic behavior initiatives during the process of strategic context determination.

Feeding back our computational findings (Proposition **1**) to the broader longitudinal field research about Intel's strategic evolution reveals that *emaciating* the strategic context determination process for assessing autonomous strategic behavior (Burgelman, 2002) constitutes an important manifestation of strategic myopia, which may lead to strategic inertia (McKinley et al., 2014). At Intel, as previously noted, Andy Grove faced this important hazard. In spite of his efforts to vectorize everybody in the same direction during his highly successful tenure as CEO, numerous autonomous strategic initiatives, in particular the networking business, continued to emerge. The decrease in Intel's capacity to activate strategic context determination processes, however, prevented the company from exploiting the potentially viable autonomous initiatives.

Autonomous strategic behavior in relation to Intel's emergent networking business run by a highly regarded senior executive provided a strong case in point. Given the generally high regard for Grove's strategic leadership as Intel's CEO, his approach to dealing with the networking business offers potentially valuable lessons. Grove's expectation that statements from senior executives associated with businesses that they are highly familiar with should be mostly right seems appropriate. In relation to autonomous strategic initiatives, however, such expectations are potentially misleading because such initiatives engage the company in new product-market spaces where the existing organizational knowledge is relatively low and new knowledge about these spaces augments existing organizational learning. Emaciating the strategic context determination process is therefore a distinctly powerful source of strategic myopia associated with co-evolutionary lock-in of a highly successful organization with its existing environment. It is a testament to Grove's intellectual acuity that he knew the danger and also that he was vulnerable to committing errors of omission (not seeing a "seed" through to growth stage) of this nature. As Tripsas and Gavetti (2000) point out, strategic myopia may potentially lead to neglecting promising opportunities outside what top management consider the "organizational identity."

Related to Proposition **2**, not providing a sufficient time horizon for allowing autonomous strategic behavior to demonstrate its potential for meaningfully augmenting organizational knowledge constitutes the important hazard of strategic impatience. Kogut and Zander (1992, p. 393), for instance, suggest that it is necessary "to buffer internal ventures from an immediate market test." This widely noticed hazard has been referred to, for instance, in management and organizational behavior (Iyer and Davenport, 2008; König et al., 2013), political science (Brennan, 2008; Lister, 2016; Nazareth, 2019; Park, 2018), development studies (Shin, 2016; Toloraya, 2019), and sociology (Han, 2019).

Proposition **2** should help organizational members involved in autonomous strategic behavior initiatives realize that top management's ability to continue to distinguish the outcomes of their efforts in terms of new knowledge development through increasing the rate of exploitation is likely to determine the extent of their patience. Craig Barrett, Andy Grove's successor as Intel CEO, stated his approach to patience (Burgelman, 2002a: 339).

> *For the people involved with the new ventures, I am sure they see us as being impatient. What I tell them is, show me how you're going to be number 1 or number 2, and how you're going to build a viable business. If they cannot do this, then we are not going to be patient. … My philosophy is to deal out patience in small dose*.

Barrett's approach confirms findings of other field studies, such as Kannan-Narasimhan and Lawrence (2018 that the burden of proof rests squarely with the agents engaging in autonomous strategic behavior. It also suggests that there continue to be great opportunities for strategy-as-practice research to augment the tools available to both agents and top management for improving the strategic management of autonomous strategic behavior (Burgelman et al., 2018)

Our combined findings also throw further light on the phenomenon of top management resistance to strategic change. Friesl and Kwon (2017, p. 103) note that "Top management resistance … reduces the consideration of alternative strategic options, thereby creating or reinforcing a strategic path that a firm might find hard to deviate from (Garud et al., 2010; Leonard-Barton, 1992; Schreyogg and Sydow, 2011; Sydow et al., 2009)."

More broadly, our combined findings extend the knowledge-based theory of strategic management. They suggest that evaluating exploration through autonomous strategic behavior by changing the rate of exploitation may help top management resolve the issue that "switching to new capabilities is difficult, as neither the knowledge embedded in the current relationships and principles is well understood, nor the social fabric required to support the new learning known." (Kogut and Zander 1992: 396). It also responds to the call to ground theorizing in "what we … choose to ignore, namely managers' experiences and practices" (Spender, 2008: 159).

Furthermore, our combined findings help formalize an important principle (Tsoukas and Mylonopoulos, 2003): "Knowledge is created by human beings who carry out work and interact in the context of social practices" (Grant, 2002: 138). They also highlight further the reasonable but relatively under-researched importance top management may give to autonomous strategic behavior as a source of knowledge development of new technical (Keil et al., 2009) or ecosystem building competence (Burgelman, 2002), or even to change strategic direction (Mirabeau and Maguire, 2014).

Our combined findings thus suggest the need to develop a broader theoretical perspective for prescribing means for exerting top management strategic control. More specifically, they suggest the potential usefulness of *complementing* theories prescribing constant surveillance of employee actions and directing employee behavior tightly in alignment with preset goals by a regimen of incentives and disincentives (e.g., Jensen and Meckling, 1976; Williamson, 1981). They suggest a mechanism by which top management is able to assess progress about strategic initiatives involving exploration through autonomous experimentation when controlling employee behavior based on alignment to preset goals is difficult or even impossible.

Finally, while our study does not examine "open innovation" initiatives (see, for example, Dobusch et al., 2019), its implications may be relevant because they help us infer under what conditions top management might allow opening up its innovation processes outside the boundaries of the organization. In addition, and related to diversity, our findings could be relevant for the emerging literature on "open strategy" (e.g., Whittington et al., 2011; Seidl et al., 2019) that concerns the participation and inclusion from previously excluded actors in the strategy development processes.

7.0 Conclusion and Implications

We combine two relatively rare research endeavors in strategic management. First, a somewhat overlooked insight from earlier field research of internal corporate venturing about the importance of new organizational knowledge development for securing top management support for autonomous strategic behavior motivated us to re-examine received field research findings about Intel Corporation's strategic evolution. Second, the new insights generated by re-examining the Intel field research motivated us to consider how we could use March's (1991) computational model about organizational learning to systematically deepen our new insights into the relationship between autonomous strategic behavior and top management control through changing the rate of exploitation.

Combining these two study threads helped us to discover behavioral patterns that otherwise would have remained hidden. Our computational analysis indicates that changing the rate of exploitation, in the sense of top management assessing the extent to which autonomous strategic behavior augments the existing organizational learning (as embodied in the existing corporate strategy), may serve as a lever for deciding when to support and when to stop autonomous strategic behavior. This implies that modulating the rate of exploitation may be a useful additional top management tool for assessing the value of autonomous strategic behavior during the process of strategic context determination; and ultimately whether it warrants amending the corporate strategy. Our analysis also indicates the conditions of environmental turbulence under which this lever of managerial control is likely to be most effective. In addition, feeding our computational findings back to findings about Intel's strategic evolution helped elucidate further systematic hazards associated with top management control of autonomous strategic behavior.

These combined findings may be useful to direct further research of autonomous strategic behavior, as well as strategy-as-practice research, to develop tools for managing it more effectively. Further research could also help determine whether companies that invest in getting better at detecting change in organizational knowledge upon changing the rate of exploitation are also better able to activate and conclude the process of strategic context determination and thereby capture more opportunities for innovation than companies that are weaker in detection such change.

Finally, our combined computational and field research findings also suggest a move in practice away from casting top management's role in terms of "exerting control" to one of "assessing effectiveness" of autonomous experimentation, where effectiveness is defined in terms of the significance (or lack thereof) of autonomous strategic behavior in augmenting organizational learning.

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Table 1. Parameters in the simulation experiments

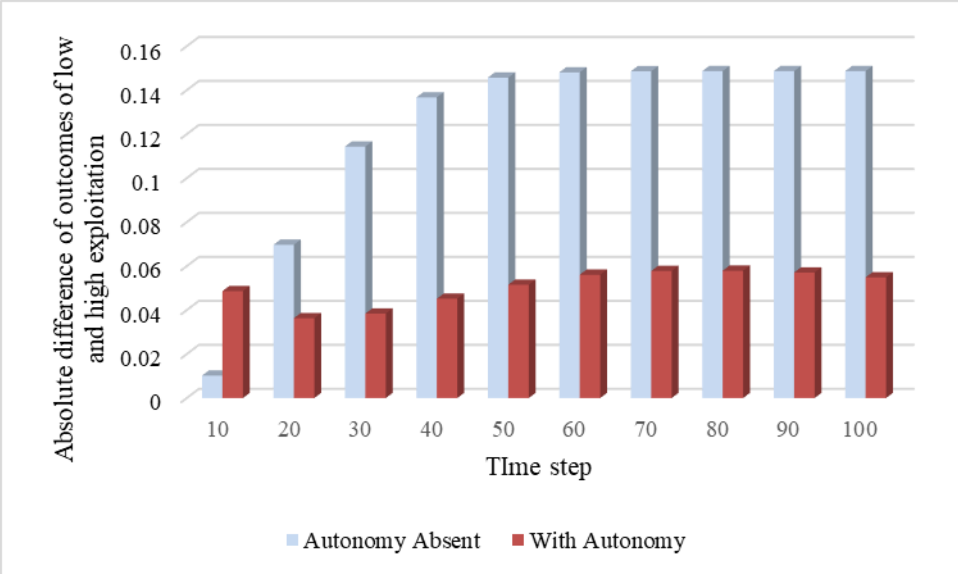
Parameter	Description	Value in experiments	Robustness check
M	The number of bits of (i) reality string, (ii) organizational code (CSOC) and (iii) member belief string	30	25, 35
N	The number of members in the organization undertaking autonomous experimentation	50	40, 60
p_1	Member learning rate, low & high rate of exploitation	0.10 & 0.90	
p_2	The rate of learning by the commandeered section of the organizational code (CSOC) corresponding to the autonomous experimentation initiative	0.50	0.40, 0.60
p_4	Zero value signifies a stable environment. A non-zero (positive) value signifies environmental turbulence and indicates the probability that a bit of *reality* flips at any time-step.	0, 0.002 to 0.02	N/A
p_5	The proportion of belief dimensions that are randomized, for a subset (25%) of organizational members, when autonomy is granted to obtain heterogeneous knowledge from outside the organization	0.10	0.08, 0.12
Alignment of initial organizational member knowledge, with respect to the level of knowledge associated with current corporate strategy (v_def)	*Initial organizational member knowledge* is moderate and aligned to knowledge associated with current corporate strategy if all beliefs are random draw from the set {-1, 0, +1}, i.e., $v\_def = 0$, at the beginning of a simulation experiment (*Marchian* populations). It is non-aligned if certain percentage of member beliefs—originally created by random draw—are overwritten with values opposite that of values in corresponding bit positions of the initial reality string, (i.e., $v\_def > 0$) at the beginning of a simulation experiment (*sub-Marchian* populations).	0 0.15	N/A 0.14, 0.16

Table 2. Summary of the findings from the research, stable or moderately turbulent environment.

	Top management **prohibits** obtaining heterogeneous new knowledge from outside the organization	Top management **permits** obtaining heterogeneous new knowledge from outside the organization
Initial organizational member knowledge in the autonomous project **aligned** to the knowledge underlying current corporate strategy	(**I**) Top management **can detect** significant change in organizational knowledge upon changing the rate of exploitation [Fig 3A, Light-colored bars in Figure 1]	(**II**) Top management **cannot detect** significant change in organizational knowledge upon changing the rate of exploitation [Fig 3B, Dark-colored bars in Figure 1]
Initial organizational member knowledge in the autonomous project **substantially non-aligned** to the knowledge underlying current corporate strategy	(**III**) Top management **cannot detect** significant change in organizational knowledge upon changing the rate of exploitation [Fig 4A, Light-colored bars in Figure 2]	(**IV**) Top management **can detect** significant change in organizational knowledge upon changing the rate of exploitation [Fig 4B, Dark-colored bars in Figure 2]

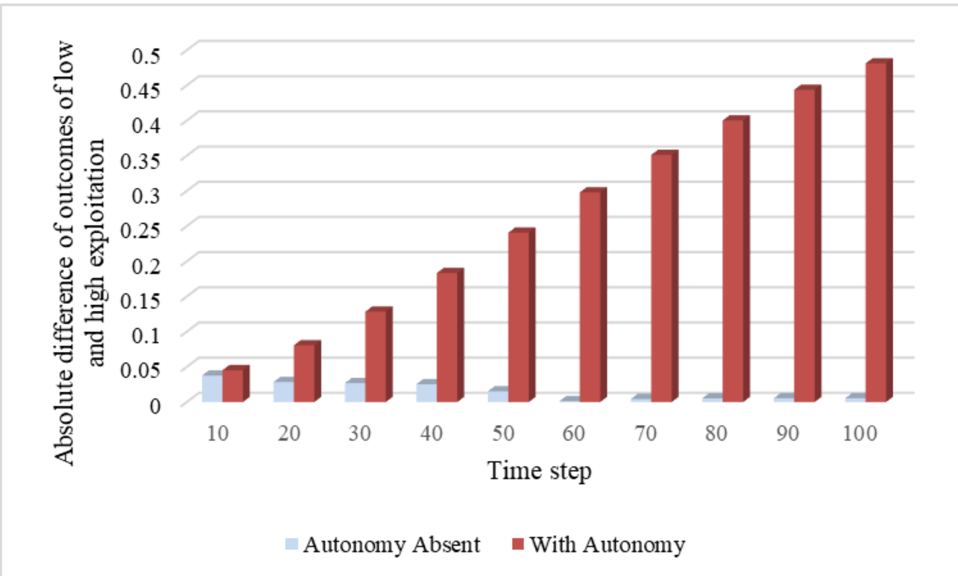
Note 1. Projects in quadrant (II) face termination risk.
Note 2. Projects in quadrant (IV) are likely to get sustained top management support.

Figure 1. Difference in outcomes between low and high exploitation, with and without approval to obtain heterogeneous external knowledge, ***Marchian*** populations, ***stable*** environment.



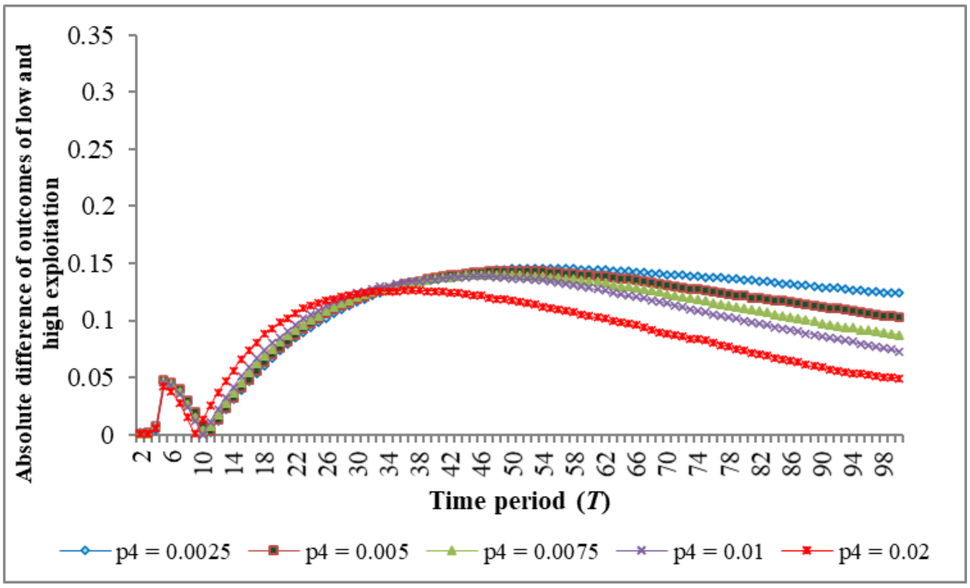
Parameters. ***M*** *= 30,* ***N*** *= 50,* p_2 = 0.50, p_1 = 0.90 for high exploitation, p_1 = 0.10 for low exploitation, p_5 = 0 when obtaining heterogeneous external knowledge is prohibited, p_5 = 0.10 when obtaining heterogeneous external knowledge is permitted, p_4 = 0, *v_def = 0* (*Marchian* populations), 10,000 iterations.

Figure 2. Difference in outcomes between low and high exploitation, with and without approval to obtain heterogeneous external knowledge, ***sub-Marchian*** populations, ***stable*** environment.



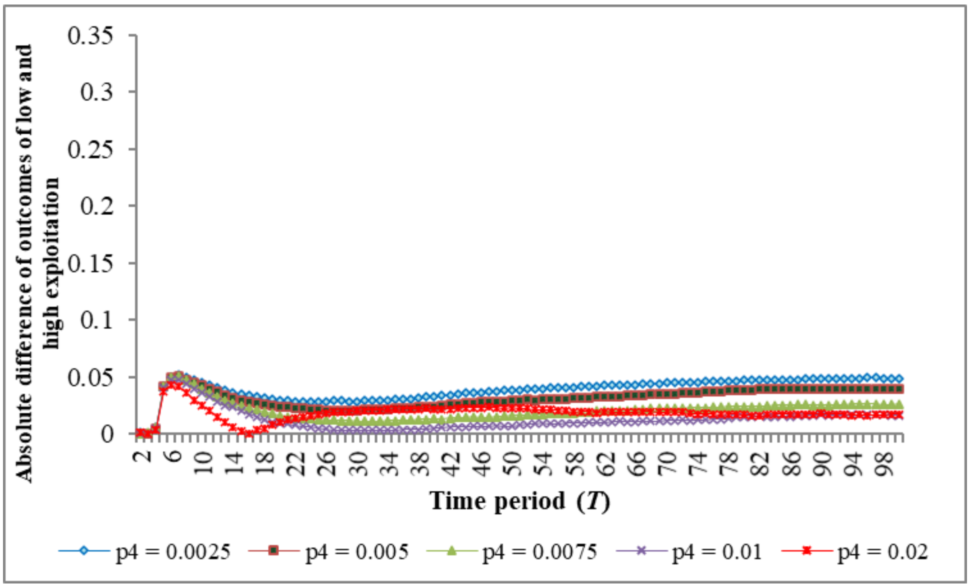
Parameters. ***M*** *= 30,* ***N*** *= 50,* p_2 = 0.50, p_1 = 0.90 for high exploitation, p_1 = 0.10 for low exploitation, p_5 = 0 when obtaining heterogeneous external knowledge is prohibited, p_5 = 0.10 when obtaining heterogeneous external knowledge is permitted, p_4 = 0, *v_def* = 0.15 (*sub-Marchian* populations), 10,000 iterations.

Figure 3A. Difference in outcomes between low and high exploitation, ***Marchian*** populations, under **varying levels of environmental dynamism,** obtaining heterogeneous external knowledge prohibited.



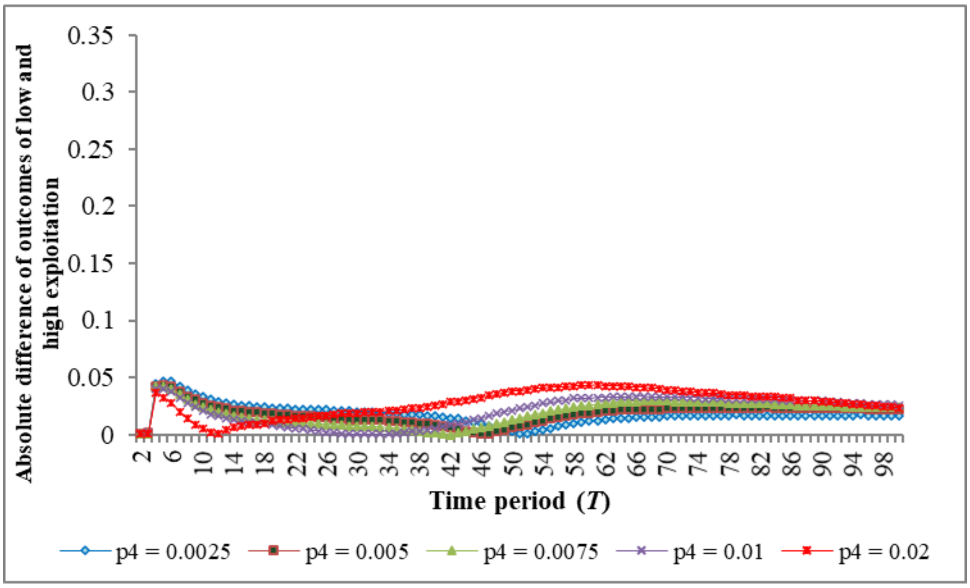
Parameters. ***M*** *= 30,* ***N*** *= 50,* p_2 = 0.50, p_1 = 0.90 for high exploitation, p_1 = 0.10 for low exploitation, p_5 = 0, *v_def* = 0 (*Marchian* populations), 10,000 iterations.

Figure 3B. Difference in outcomes between low and high exploitation, ***Marchian*** populations, under **varying levels of environmental dynamism,** obtaining heterogeneous external knowledge permitted.



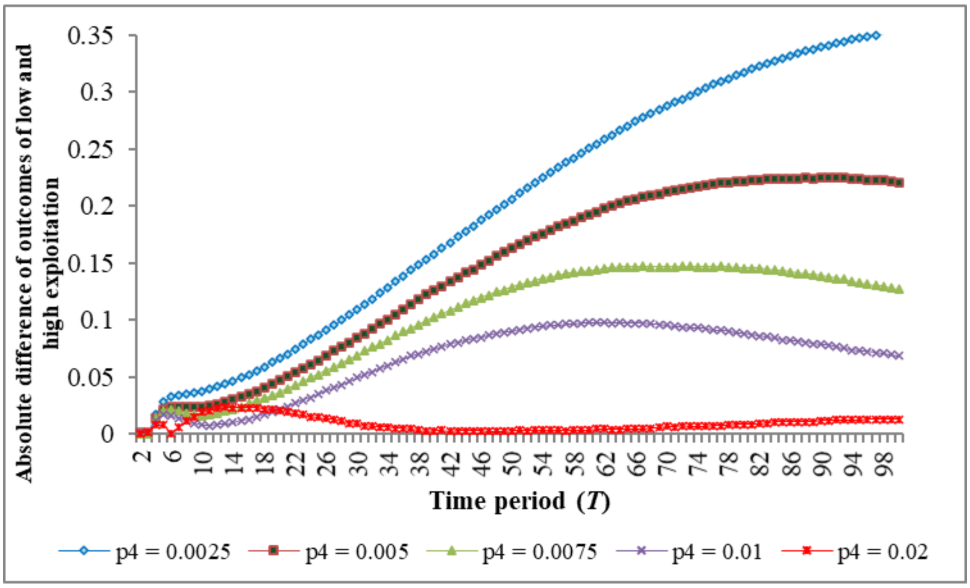
Parameters. ***M*** *= 30,* ***N*** *= 50,* p_2 = 0.50, p_1 = 0.90 for high exploitation, p_1 = 0.10 for low exploitation, p_5 = 0.10, *v_def* = 0 (*Marchian* populations), 10,000 iterations.

Figure 4A. Difference in outcomes between low and high exploitation, ***sub-Marchian*** populations, under **varying levels of environmental dynamism,** obtaining heterogeneous external knowledge prohibited.



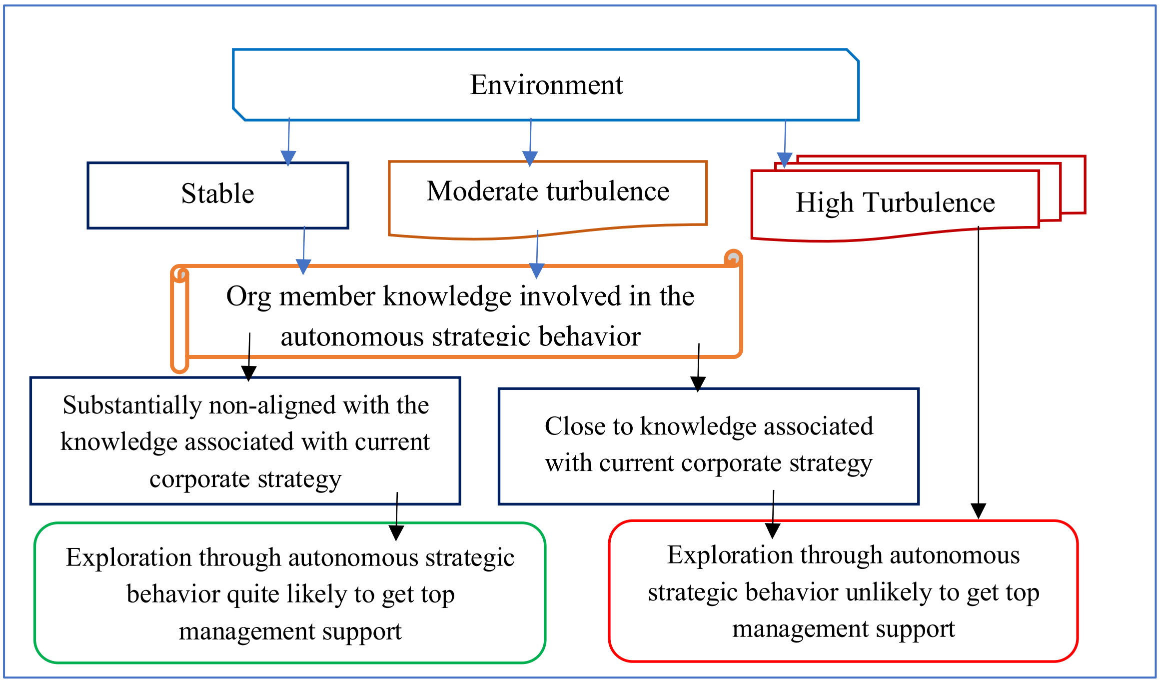
Parameters. ***M*** *= 30,* ***N*** *= 50,* $\boldsymbol{p_2}$ = 0.50, $\boldsymbol{p_1}$ = 0.90 for high exploitation, $\boldsymbol{p_1}$ = 0.10 for low exploitation, $\boldsymbol{p_5}$ = 0, *v_def* = 0.15 (*sub-Marchian* populations), 10,000 iterations.

Figure 4B. Difference in outcomes between low and high exploitation, ***sub-Marchian*** populations, under **varying levels of environmental dynamism,** obtaining heterogeneous external knowledge permitted.



Parameters. ***M*** *= 30,* ***N*** *= 50,* $\boldsymbol{p_2}$ = 0.50, $\boldsymbol{p_1}$ = 0.90 for high exploitation, $\boldsymbol{p_1}$ = 0.10 for low exploitation, $\boldsymbol{p_5}$ = 0.10, *v_def* = 0.15 (*sub-Marchian* populations), 10,000 iterations.

Figure 5. Schematic diagram for the theoretical propositions

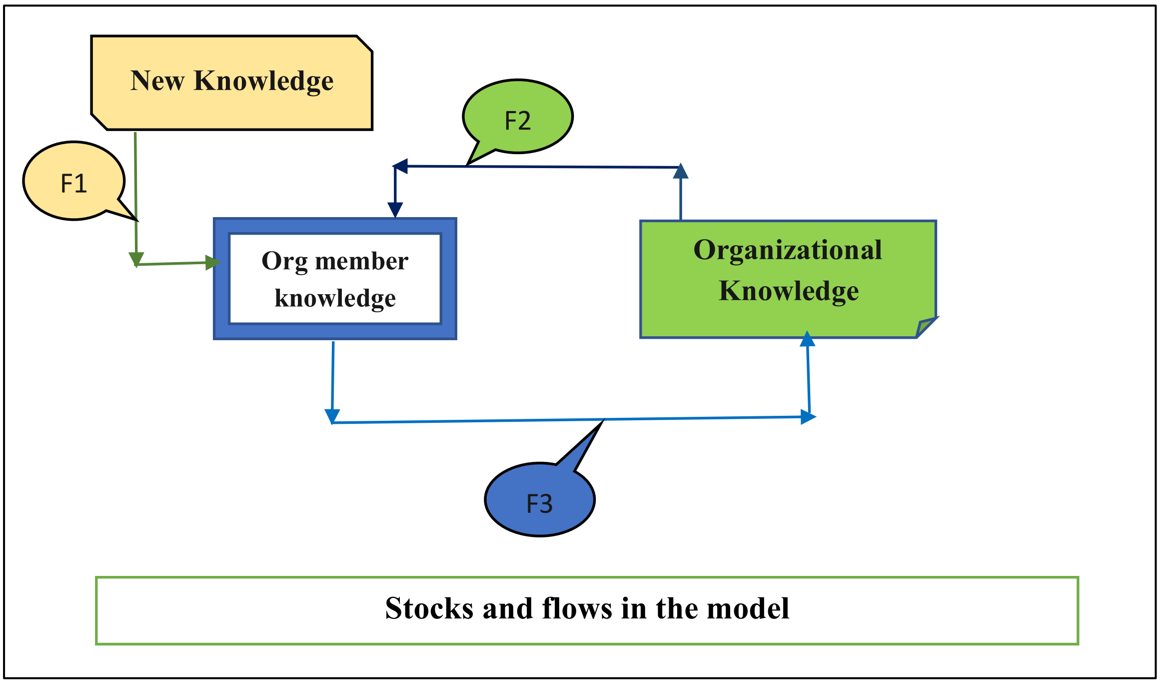


APPENDIX

Stocks and flows in the simulation model

In **Figure A1** we provide a schematic diagram for the model mechanics underlying the March (1991) model pertaining to exploration through autonomous experimentation in terms of joint consideration of stocks and flows (Dierickx and Cool, 1989). This diagram shows the process of organizational knowledge development—relating back to March's organizational learning metaphor to describe the principles of exploration and exploitation.

Figure A1. Schematic diagram for stocks and flows in the model



Stocks and Flows

In all, there are three ***stock*** variables and three flow rates connecting them.

- Stock Variable #1 is "New Knowledge". We alternately refer to this as "heterogeneous new knowledge from outside the organization". The source (or container) of "New Knowledge" constitutes academic and research institutions, consultants, industry trade body meets and conferences etc. consulted by the organizational members involved in exploration through autonomous experimentation.
- Stock Variable #2 is "organizational member knowledge" It is the stock of knowledge held by organizational members involved in the autonomous experimentation (in their heads).
- Stock Variable #3 is "organizational knowledge" developed by the team undertaking the autonomous experimentation initiative. The team undertaking autonomous

experimentation commandeers a segment of the official organizational code to house databases, rules, norms, forms, procedures etc. associated with the autonomous experimentation initiative. Thus, "organizational knowledge" developed by the team undertaking the autonomous experimentation initiative resides in the "commandeered segment of the organizational code" (CSOC).

The ***flow*** variables work as follows:

- First, if exploration through autonomous experimentation is permitted, the knowledge of organizational members involved in the autonomous experimentation initiative gets enriched by heterogeneous new knowledge from say, interactions with academic and research institutions, consultants, by members attending conferences, trade body meets and so forth. The corresponding flow is **F1**. In the simulation model, **F1** is represented by having p_5 greater than zero.
- Second, the rate of members learning from the CSOC is represented by the flow **F2**, corresponding to the variable p_1 in the computational simulation model (representing exploitation). In this case the stock of org member knowledge gets modified by the flow **F2** from the stock representing organizational knowledge developed by the team undertaking the autonomous experimentation initiative.
- The flow **F3**—corresponding to the variable p_2 in the computational simulation model—depicts the process of the organizational code learning from members. Here the stock of organizational knowledge gets updated from the stock of org member knowledge by the flow **F3**. In order to keep the scope manageable, in our study, we choose to keep p_2 the same throughout (other than for robustness check); likewise, we also choose to have the flow **F1** as an ON/OFF parameter signifying autonomous experimentation is permitted / not permitted.

Model Mechanics

(**I**) When obtaining heterogeneous new knowledge from outside the organization is permitted, the stock of knowledge of members undertaking an autonomous experimentation initiative gets updated by the flow **F1** (modeled by setting the variable p_5 to a value greater than zero) from, say, interaction with industry and academic institutions, attending conferences and trade body meetings, etc. Both correct and incorrect knowledge can come in the updates to the knowledge of members of the autonomous experimentation team (given that random values from {-1, 0, +1} with one-third probability are used to update member belief dimensions).

(**II**) Even otherwise, the stock of member knowledge is updated from the stock of **organizational knowledge** acquired by the team undertaking the autonomous experimentation initiative by the flow **F2** (modeled by the variable p_1) whereby any given member learns from the CSOC.

(**III**) Lastly, the stock of **organizational knowledge** is updated by the flow **F3** (modeled by the variable p_2) from the stock of org member knowledge. Via the flow **F3**, the CSOC learns from the subset of *members carrying superior knowledge* (MCSK) in the team involved in performing autonomous experiments. In any given time-step, the CSOC gets correct and incorrect knowledge as input when there is correct and incorrect groupthink among the MCSK, respectively.

(**IV**) We note that once a member learns the "generally known stuff" in the CSOC, he/she stands a greater chance of being inducted into the team of the MCSK that advise the CSOC. Thereafter, a member's unique valuable knowledge in some other dimension can help to increase the organizational knowledge in the CSOC. Such happens by driving out incorrect knowledge in the corresponding CSOC dimension that might have been acquired earlier (due to incorrect groupthink among the the-then MCSK).

(**V**) The level of organizational knowledge reached by the CSOC on account of repeated occurrence of (**IV**) is a function of several parameters. First, the extent of alignment of the initial organizational member knowledge with the knowledge associated with the firm's current strategy. Second, the state of the environment (stable / turbulent). Third, the rate of external heterogeneity infusion (p_5), the rate of exploitation (p_1) and the rate of learning by the CSOC (p_2). For any given configuration of values in these parameters, the level of organizational knowledge is likely to 'settle' to oscillating near a particular value, given that this is an open system.