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Competitive Dynamics of Business Process Improvement

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ABSTRACT

We offer a theory of competitive process improvement to explain the process of how best business practices emerge through dynamic interactions between competing processes. Grounded on the history of the interaction between two distinctive competing processes, Mass Production System vs. Toyota Production System, we employ the lens of competitive dynamics to develop a formal model. Three insights emerged: for sustainable competitive advantage, (1) a firm needs to invest in explorative activities at an early and continuous fashion; (2) external competitive tension plays a vital role in managing internal tension of organizational learning; (3) a firm may commit perception biases when interpreting others' learning (re)actions.

Keywords: Process improvement; competitive dynamics; simulation.

The study of business process improvement has greatly attracted the attention of academics and practitioners (e.g. Repenning and Sterman 2001, 2002; Singhal and Singhal 2007; Sprague 2007). The major reason is the significant economic benefits achieved by the successful implementation of process improvement programs such as Total Quality Management (TQM) (Rohleder and Silver 1997). In manufacturing industries, for instance Toyota Production System (TPS) is famous for its shift from the flexibility-and-efficiency tradeoff to attain both superior flexibility and efficiency in operational processes (Adler et al. 1999; Lin et al. 2007; Schonberger 2007). TPS has been well recognized as revealing one of the "best practices" in operational processes and as being a role model for Western competitors to imitate.

The extant research mainly emphasizes the tactical drivers, such as improving the current operational capability and the associated economic benefits, without considering competition (e.g. Rohleder and Silver 1997). The literature on operations management and organization theory, for example, has greatly investigated the 'ambidexterity' in TPS evolvement and the impact of the associated tactics such as lean operations, Just-in-Time (JIT), jidoka (automation defect detection and machine stop), total quality control (TQC), and continuous improvement (kaizen) on firm performance (Collinson and Wilson 2006; Fujimoto 1999; Holweg 2007). However, from the

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viewpoint of competitive strategy (Porter 1980), the adoption of best practice in business process could be treated as a strategic weapon to improve competitive position for rent generation. Thus, we argue that the history of business process improvement evolution, e.g. from Mass Production System (MPS) to TPS in car manufacturing, should be viewed as the evolution of *competitive process improvement*, that is, 'a process and its resulted performance will evolve during the action-reaction responses against its competing process over time.'

This paper adopts the lens of "competitive dynamics (CD)" in the strategy literature to analyze firm-level competition in process improvement and attempts to construct a casual mechanism through which best practice is 'recognized', 'imitated' and 'developed.' We aim to: (1) provide a firm-level analysis for competitive dynamics between two organizations' business process (rather than focusing on only one single organization as previous studies); (2) build a formal model for the proposed theoretical framework; (3) develop theory of competitive process improvement through simulations generated from our model.

The paper is structured as follows: first, the evolution history of TPS against MPS is briefly reviewed to provide the grounding context; then, by employing the constructs of "market commonality" (Chen 1996), "resource similarity" (Chen 1996), and "competitive tension" (Chen et al. 2007), we propose a paired-comparison framework of competing process improvement and build a formal model from the perspective of "Awareness-Motivation-Capability" (A-M-C) framework (Chen 1996; Chen et al. 2007); computer experiments are conducted through simulations to explore the competitive actions and reactions in improving organizational performance from not only conventional tactical aspect but also strategic aspect; finally, we develop a number of theoretical propositions and discuss several managerial implications and future research.

Case Background: Craft Production to MPS to TPS

From the days of Craft Production (CP), to the rise of MPS, then to the thriving of TPS, the evolution of business process systems in the automobile industry has been comprehensively studied along with the corresponding great corporate success stories like Ford, General Motors (GM), and Toyota (Holweg 2007; Sprague 2007). Particularly, the stories of Toyota and TPS, as well as the associated impressive operational performance have been repeated countless times over the past 20 years.

In the CP age, the operational system relied on highly skilled workers and simple but flexible tools to satisfy the individual needs of the customers once at a time (Womack et al. 1990). While the craft producers were making exactly what the customer asked, goods were too costly to afford for most people. Hence, MPS was developed at the beginning of the twentieth century as a competing process against CP in order to achieve higher productivity, simpler manufacturing, and consistent quality (Womack et al. 1990).

With the support of the revolutionary Scientific Management philosophy, MPS was a promising standardized process that was adopted and further developed by Henry Ford at Ford and Alfred Sloan at GM (Rother 2009; Sprague 2007). The use of semiskilled or unskilled workers and expensive, single-purpose machines was the key to gain high performance in operational process. The substantial improvement for production process though MPS allowed customers to get cheaper products, but at the expense of variety (Holweg 2007; Womack et al. 1990).

With the widespread recognition and diffusion of MPS across the world, Ford and GM were losing their competitive advantage since late 1950s (Sprague 2007). While most of the American CP firms and the European competitors directly imitated the basic fundamental underlying MPS to make the transition, Taiichi Ohno changed the rules of competition in car manufacturing process (Fujimoto 1999; Holweg 2007; Womack et al. 1990).

Rather than adopting all the principles of MPS with no doubt, Ohno started his learning of American pioneers from observation, to question, and then tried to find solutions via experimentation (Fujimoto 1999; Ohno 1988; Rother 2009). For example, by analyzing the American competitors' processes, Ohno discovered one logical flaw in MPS: Mass producers added a lot of buffers (e.g. extra workers and extra space) to ensure smooth production as the machinery was expensive and intolerant of disruption. Ohno started his experimentation of small-lot production throughout Toyota for reducing production costs by eliminating wastes of any material or machine time (Schonberger 2007; Womack et al. 1990). Later, Toyota developed its own philosophy that "the best way to work would be to have all the parts for assembly at the side of the line just in time for its user" (Ohno 1988, 75). Eventually, TPS successfully challenged the widely accepted MPS practice in the industry, significantly resolving the dilemma between productivity and quality (Holweg 2007). Nowadays, Toyota has passed GM and Ford as the world's largest automotive producer and has been one of the most consistently successful global enterprises over the past fifty years (Rother 2009; Sprague 2007).

Numbers of studies (e.g. Fujimoto 1999; Schonberger 2007; Womack et al. 1990) point out that TPS is famous for its employment of multi-skilled team members at all levels of the organization and flexible machines to produce products in enormous variety. In fact, the spirit of TPS is a synthesis of CP and MPS; but, it does not have the high cost of the former and the rigidity of the latter (Sprague 2007; Womack et al. 1990). As argued by Fujimoto, Toyota adopted the MPS principles in a selective way, taking the consideration of the constraints of the domestic market and existing capabilities.

> *"While its initial attempts were more or less imitation and a patchwork of American automobile technologies, in both product and process, Toyota was an active receiver of the technologies in combining them and adapting them into Japanese conditions. Kiichiro did not try to introduce the Ford system directly, but did apply its elements selectively to Japan (small market, bad roads, etc.), in both product and process technology" (Fujimoto 1999, 36).*

Therefore, it is a myth that Toyota purely invented the genius production process. TPS was actually developed and evolved on the basis of MPS and the two systems have obvious continuity.

Process improvement in industry would be always nonstop with the existence of competition. As argued before, it is commonly believed that Toyota's enduring success could be attributed to the successful implementation of TPS (Lewis 2000). To compete with Toyota in the worldwide, numbers of manufacturers including GM, Ford, and Chrysler have adopted TPS as the benchmark and developed Toyota-like operational processes in the hope of replicating Toyota's success (Spear 2004; Spear and Bowen, 1999). Although it currently seemed almost no company outside Toyota's family has ever been able to match Toyota's systematic and continuous improvement in quality and cost competitiveness, Western companies have shown impressive improvements in operational performance such as inventory management in 1990s (Schonberger

2007; Rother 2009). Given competitors' vigorous initiatives to explore TPS and Toyota's continuous improvement to sustain competitive advantage, it is thus expected to see another significant process improvement in the future combined both advantages of TPS and Western innovation.

Theoretical Background

Business Process Improvement: A Competitive Dynamics Lens

The history of management practice is filled with process improvement and innovation diffusion (e.g. Keating et al. 1999; Repenning 2002; Sood and Tellis 2005). Process improvement has become an imperative for organizations to seek competitive advantage over competitors due to the significant economic benefits achieved by its successful implementation (Rohleder and Silver 1997). The notion here is consistent with the central topic in organizational theory that organizations always need to improve their existing capabilities for survival and growth (e.g. Repenning and Sterman 2002; Zollo and Winter 2002). Developing organizational capabilities is tightly connected with a firm's performance in competitive environments (Teece et al. 1997; Zott 2003). As illustrated in the previous section, the famed TPS is recognized as the major contributor to the consistently outstanding performance of Toyota for the past fifty years (Fujimoto 1999; Spear 2004). Through the competing history between these two operational processes (CP vs. MPS, MPS vs. TPS), it could be observed that the superior process evolved during the interactions against its competing process over time. Normally, the improvement has been neither purely original nor totally imitative, explained below.

There are two possible tensions in competitive process improvement to capture its hybrid nature of partial imitation and partial experimentation. One is between competing processes (e.g. my current process vs. my rival's process) from the external view. The other is from the internal view to improve the process by facing another tension between adoption of existing processes and creation of new ones.

From the perspective of internal tension, both management researchers and organizational theorists recognize that the decision to change and build up operational practices, i.e. "routines", and capabilities is of significant importance to any organization (Peng et al. 2007; Tranfield and Smith 1998; Zott 2003). The generic term of routines includes the forms, rules, procedures, conventions, strategies, technologies, and so forth around which organizations are constructed and through which they operate (Levitt and March 1988). It also includes the structure of beliefs, frameworks, paradigms, codes, cultures, and knowledge, acting as repositories for tacit knowledge (Becker 2004) and a form of organizational memory (Cohen and Bacdayan 1994). The tactics to develop organizational routines and dynamic capabilities have been greatly studied (Adler et al. 1999; Nelson and Winter 1982; Teece et al. 1997). According to March (1991), on the one hand organizations could select and adopt routines through imitation from the existing routine pool; on the other hand, they could change existing routines through searching new routines via experimentation to generate economic rent. Effective selection from best practices is essential to survival and development, but so is the creation of new ones (Adner and Levinthal 2008; March 1991; Haveman 1993).

The literature on process improvement is silent on the issue of external tension between competing processes (Anand et al. 2009). The previous research lacks strategic considerations

such as the first/second mover dis/advantage, and often overlooks the initial introduction of improvement activities. Consequently, the possible interactions between internal tension and external tension were completely ignored in the literature. In fact, the success or failure of an organization's competitive interactions and the associated competitive advantage heavily depends on responses and nonresponses of its competitors (Chen and MacMillan 1992; McGrath et al. 1998). Failure to improve organizational capabilities frequently occurs when organizations are unaware of a need to change, i.e. insensitive to external tension. Further, organizations threatened with performance decline due to the fierce competition are more willing to commit to strategic improvement (Gilbert 2005). In sum, business process improvement could be viewed as triggered by the 'awareness' (A) of superior routines, i.e. best practice here, and the resulting impact on organizational performance, followed by the 'motivation' (M) to initiate learning, and supported by the 'capability' (C) to take (re)actions (Chen et al. 2007). Thus, the A-M-C framework in the CD literature should be adopted as a means to understand business process improvement.

Accordingly, the CD lens is suitable to capture the essence of both internal and external tensions. We believe that embracing this lens can make significant contribution to the understanding of the dynamic features of competitive action and response between competing business processes (Chen 1996; Smith et al. 1991). In general, CD research provides a dyad-level analysis at which "actual competitive engagement occurs, in which competitors enact their strategies, test their opponents' mettle and capabilities" (Chen and MacMillan 1992, 541). Two firms are said to be *rivals* if they compete in shared markets and if each firm is aware that the effects of its own decision depend on how its competitor respond. A *competitive move* is defined as an action that has the perceived effect at the expense of its rivals or of reducing the anticipated returns to rivals (Smith et al. 1991).

In this study, we consider a duopoly for the analysis of competitive interaction to achieve process improvement in the viewpoint of rent searching. One is named as *leader* (he), who maintains dominant position in industry due to the employment of the current best practice. The other is named as *follower* (she), who intends to improve its strategic position through imitating the leader's operational process or creating new operational process. By simultaneously considering the internal and external tensions, we employ three well-known constructs in the CD literature, "market commonality" (Chen 1996), "resource similarity" (Chen 1996), along with "competitive tension" (Chen et al. 2007), to specify the casual mechanism through which the best practice in industry is recognized, imitated and developed over time. The details for these constructs are as follows.

Market Commonality

Market commonality is defined by Chen (1996, 106) as the "degree of presence that a competitor manifests in the markets it overlaps with the focal firm." The notion of market commonality is derived from the research on multimarket competition, emphasizing on the existence of sharing distinct markets via dynamic interactions (Baum and Korn 1999; Gimeno and Woo 1996). This construct is conditioned by the strategic importance to the focal firm and its market strength in these competing markets, clearly reflecting the property of relationship (instead of a property of industry, markets, or firms) between the two firms (Baum and Korn 1999; Chen and MacMillan 1992).

Resource Similarity

Resource similarity is described as "the extent to which a given competitor possesses strategic endowments comparable, in terms of both type and amount, to those of the focal firm" (Chen 1996, 107). The notion of this construct is derived from the fundamental assumption of the resource-based view that resource bundles and capabilities are heterogeneously distributed across firms and that each firm is idiosyncratic because of the different resources and assets it has acquired over time and because of the various routines it has developed to manage them (Barney 1991; Chen 1996).

Exploitation and exploration: Numbers of studies in organization theory have investigated the balance between exploration and exploitation, such as Levitt and March (1988), March (1991), Gupta Smith, and Shalley (2006), and so forth. Such trade-off relationship reflects the internal tension for competitive process improvement (Keating et al. 1999; Repenning and Sterman 2002).

Consistent with March's (1991) definition, we treat the adoption of existing knowledge and operational system as exploitative activities, no matter it is generated by the leader or the follower herself before she takes any competitive actions. Then, all the other activities involving searching and experimenting new opportunities initiated by the following firm belong to exploration. Exploitation would facilitate rapid learning from existing process, e.g. best practice that quickly changes to reflect the benchmark in the organization (Miller et al. 2006). Consequently, resource similarity is inclined to increase via exploitative activities. On the other hand, exploration can be modeled as slow learning by innovation and experimentation and often follows by feedback delay (Rahmandad et al. 2009; Repenning and Sterman 2002). As the explorative activities are driven by commitment of systematically searching new opportunities (March 1991); they are expected to lead to resource dissimilarity.

Competitive Tension

Competitive tension is frequently used in the firm dyad-level analysis (Chen 1996; Chen et al. 2007). According to Chen, Su, and Tai (2007, 103), tension describes "the state of latent strain that precipitates the 'breaking point' when strain becomes manifest through competitive actions. Thus, tension defines the forces that build up and tend to pull a static interfirm relationship into dynamic behavior interplay between rivals." This study will use the (objective) competitive tension as measurement, which relates to the ever-changing market conditions such as market commonality (Chen 1996) and multimarket contact (Baum and Korn 1999), to reflect the external tension.

Direct competition and indirect competition: We identify two variables that have impacts on the degree of competitive tension: "response delay" and "matching response" (Chen and MacMillan 1992; Chen et al. 2002; Smith et al. 1991). Response delay refers to the time interval between attacker's action and defender's response, while matching response is one specific type of reaction that defender just simply replicates what the attacker did (Chen and MacMillan 1992). An action formed by long response delay and no matching response would result in *indirect competition* that may reduce the extent of competitive tension. In contrast, an action that involves short response delay and matching response will be recognized as *direct competition* that increases competitive tension.

By considering both internal and external competitive tensions, this paper expects to use System Dynamics (SD) methodology to develop a formal model from the A-M-C perspective for competitive process improvement.

System Dynamics

According to our arguments, managing process improvement requires a dynamic orientation to be able to simultaneously analyze multiple interdependent relationships within the underlying system (Harrison et al. 2007). While the traditional methodology was static in nature, SD works as a powerful research methodology to capture on-going processes and simultaneous procedures that influence each other (Sterman 2000). This methodology is useful to produce dynamic management theory by highlighting feedback processes (i.e. circular causal relationships) in which variables influence and, in turn, respond to each other (Sastry 1997; Rudolph et al. 2009). In particular, it is vital to adopt SD in operations management, as the field is characterized by feedback, resource accumulation, and delay (Groessler et al. 2008). Hence, such method enables us to further explore the complicated and unforeseen interactions within competitive dynamics systems (Sastry 1997; Harrison et al. 2007).

Grounded on the management literature, we develop a formal model to study the evolvement of competitive process improvement in the following.

The Model: Awareness-Motivation-Capability Framework

The literature on organizational change, learning, and behavioral decision-making suggests three essential factors underling organizational actions: the awareness of interfirm relationships and action implications, the motivation to act, and the capability of taking actions (Baum and Korn 1996; Chen et al. 2002). It is consistent with the A-M-C framework (Chen 1996; Chen et al. 2007) in the CD literature that identifies an integrative framework in predicting a competitor's response. By explicitly adding competitive tension (Chen et al. 2007) into this framework, we extend the current discussion on the role of dynamic competition. Specifically, a follower's response to a leader's competitive move can be seen as a function of the visibility of the leader's action (Awareness), the follower's commitment to the existing process, organization reputation, and the associated response options (Motivation), and the efficiency and effectiveness of the options to neutralize the leader's action (Capability) (Chen and Miller 1994; Chen et al. 2007). The details about the A-M-C framework are explained as follows.

Awareness

Awareness refers to a defender's recognition of competitive action and the relationship with the attacker (Chen 1996; Chen and Miller 1994; Chen et al. 2007). The greater awareness the defender has on rival's competitive action, the greater likelihood s/he would take response. In our model, market commonality is viewed as an active indicator of defender's awareness. Multimarket contact theory agrees that, in general, the greater the degree of overlap between two firms, the higher competitive interdependence they both could recognize (Gimeno and Woo 1996), hence facilitating greater awareness and mutual understanding of each other's action.

Motivation

Motivation refers to the incentives and the subsequent decision making attitude that drive the defender's decision to retaliate (Chen 1996). Typically, a company will be highly motivated to

respond if either the returns from response or the losses from non-response are expected to be high. In addition, the extent of motivation level could be further distinguished by the defender's commitment to the attacked market (Chen and Miller 1994; Chen et al. 2007). In our model, follower's motivation can be observed via her escalating commitments to existing markets and the resulted competitive tension. If the follower is highly committed to the internal resources such as current staff capabilities, she would be more motivated to adopt the prospective rationality to differentiate herself (Rahman 1998; Staw 1981; Whyte 1986). If the follower is highly committed to external factors derived from social and institutional pressures, she would demonstrate high incentive in taking a matching response to show the commitment of defending herself (Chen et al. 2002).

Capability

Capability refers to the defender's resource deployment and the ability to engage with the attacker to implement the decision making through competitive responses (Chen 1996; Chen and Miller, 1994; Chen et al. 2007). Once determine the type of responses, either a differentiating or matching response, eventually it depends on the follower's capability to carry it out. In our model, the capability to implement the matching response depends on the level of resource similarity between the follower and the leader. Only a high similarity of the resources they have can afford the imitative activities.

Competitive Asymmetry

It must be clarified that a competitive action may not affect each of the A-M-C components equally for all given competitors (Chen 1996). It is prevalent to recognize the asymmetric relationship between leader and follower in any competition. This view point is of particular importance for the factor of awareness in our model. The competing history between TPS and MPS provides a vivid example to this point. When Ohno originally started his experimentation and explored the famed TPS in 1950s, the main elements of TPS were first known beyond Japan by Western competitors in the early 1980s (Schonberger 2007; Womack et al. 1990). The Western leaders' unawareness of the innovative development from the follower Toyota resulted in their diminished market power.

With the notion of A-M-C framework and the competitive asymmetry between the leader and the follower, we start to build causal loops to examine the mechanisms through which best practice is recognized, imitated and developed. According to our arguments, eight feedback loops are embedded in our model, as illustrated in Figure 1. At the same time, we translated them into a formal mathematical model (the detail of stock-and-flow map and equation list can be requested from the corresponding author). All the parameters are set to reflect the reasonable values in the contexts of real-world business competition.

In Figure 1, two types of casual loops are presented. One is reinforcing loop, labeled as "+"; the other is balancing loop, labeled as "−" (Sterman 2000). Reinforcing loops indicate self-reinforcing processes; and balancing loops work to close the gap between a desired and actual situation (Sterman 2000). We propose four pairs of causal loops explained under the following four subtitles. Within each pair of loops, one reinforcing loop and one balancing loop are presented in comparable to each other in order to understand the dialectic nature of the constructs.

Multimarket Contact Facilitates Higher Awareness

The construct of Market Commonality, *M*, serves as a stock in our formal SD model. As two firms meet each other in increasing number of multiple markets, their competitive interactions are recorded as a valuable type of organizational memory to prepare for future actions (Anand et al. 2009; Baum and Korn 1996, 1999). Market commonality demonstrates the aggregate relational effects of past competitive moves with the range from 0 to 1. The changes of market commonality could be determined by two factors: It is increased by 'Entry into Rival's Markets, *I*,' and decreased by 'Withdrawal from Common Markets, *E*',

$$(d / dt)\ M = I - E\ . \tag{1}$$

A high market commonality between the rivals indicates an intense competitive relationship derived from the interaction history, as the likelihood of overlap between their strategic markets is greatly increased (Baum and Korn 1996).

Multimarket contact reinforcing loop: Multimarket contact is vital for organizations to achieve firm diversity (Chen 1996; Gimeno and Woo 1999). Additionally, participating in different markets could yield a useful potential deterrent, which may signal displeasure and raise the threat of serious. Therefore, when multimarket contact is high, each firm has already established large mutual footholds, *f*, to signal his/her ability to enter each other's markets (Baum and Korn 1996; 1999). Additionally, the more retaliation capability the follower obtained in previous period, the less likely she will be forced to exit the leader's markets.

A reciprocal entry occurs, firms are becoming increasingly interdependent in multiple markets (Gimeno and Woo 1996), which provides growing availability of information about the rival and helps firms be more sensitive monitoring towards interpreting rival's intention (Boeker et al. 1997). Like our case, Ford and GM were significant players in Japan's automobile market between the mid-1920 and the mid-1930, Toyota utilized that period to study MPS in depth to fully understand its key components (Fujimoto 1999).

In the past multimarket contact studies, researchers have identified a curvilinear relationship between multimarket contact and market entry and exit with a diminishing increase rate (e.g. Baum and Korn 1999; Gemeno and Woo 1996). Hence, we propose a logarithmic relationship between Market commonality and Established Mutual Footholds:

$$f = \ln\left(M + a_1\right), \tag{2}$$

where a_1 (= 3 in the base case) is a constant set to ensure that market commonality is within the range from 0 to 1. In addition, the established mutual footholds are expected negatively related to market exit:

$$E = 1/\left(a_2 \cdot f \cdot t_w\right), \tag{3}$$

where a_2 (= 4 in the base case) is a constant to ensure that market commonality is within the range from 0 to 1, and t_w is the time duration required to withdraw from the market.

The formula to describe the positive relationship between the established market footholds and market entry is presented later to incorporate the effect from the subsequent balancing loop.

Mutual forbearance balancing loop: As multimarket contact increases and firms become more aware of their competitive interdependence (a crowding effect). The further increases in

market commonality eventually lead to mutual forbearance and competitive stability that lower the entry rate (Baum and Korn 1996; 1999). It is because the cost of an additional market entry action increases as the 'Risk of Retaliation Reaction, *r*,' also increases (Gimeno and Woo 1996). Moreover, aggressive behavior in localized markets may even evoke retaliation in all the other shared markets, thus leading to a multimarket escalation of rivalry (Gimeno and Woo 1996). Therefore, each firm has an incentive to avoid entering a new market that is currently occupied by firms that it already meets in multiple markets to discourage potential multimarket retaliation (Baum and Korn 1999). Formally:

$$r = EXP(f + a_3) + m, \tag{4}$$

where a_3 (= -3 in the base case) is a constant to ensure that market commonality is within the range from 0 to 1, and *m* represents 'Mimic Behavior' (explained later).

In sum, the specified two loops imply an inverted U-shaped relationship between multimarket contact and the rate of market entry (Baum and Korn 1996):

$$I = (f - r)/t_i, \tag{5}$$

where t_i is the time duration required to enter the leader's markets.

Market Commonality Generates Commitment Escalation and Decision Making Attitude

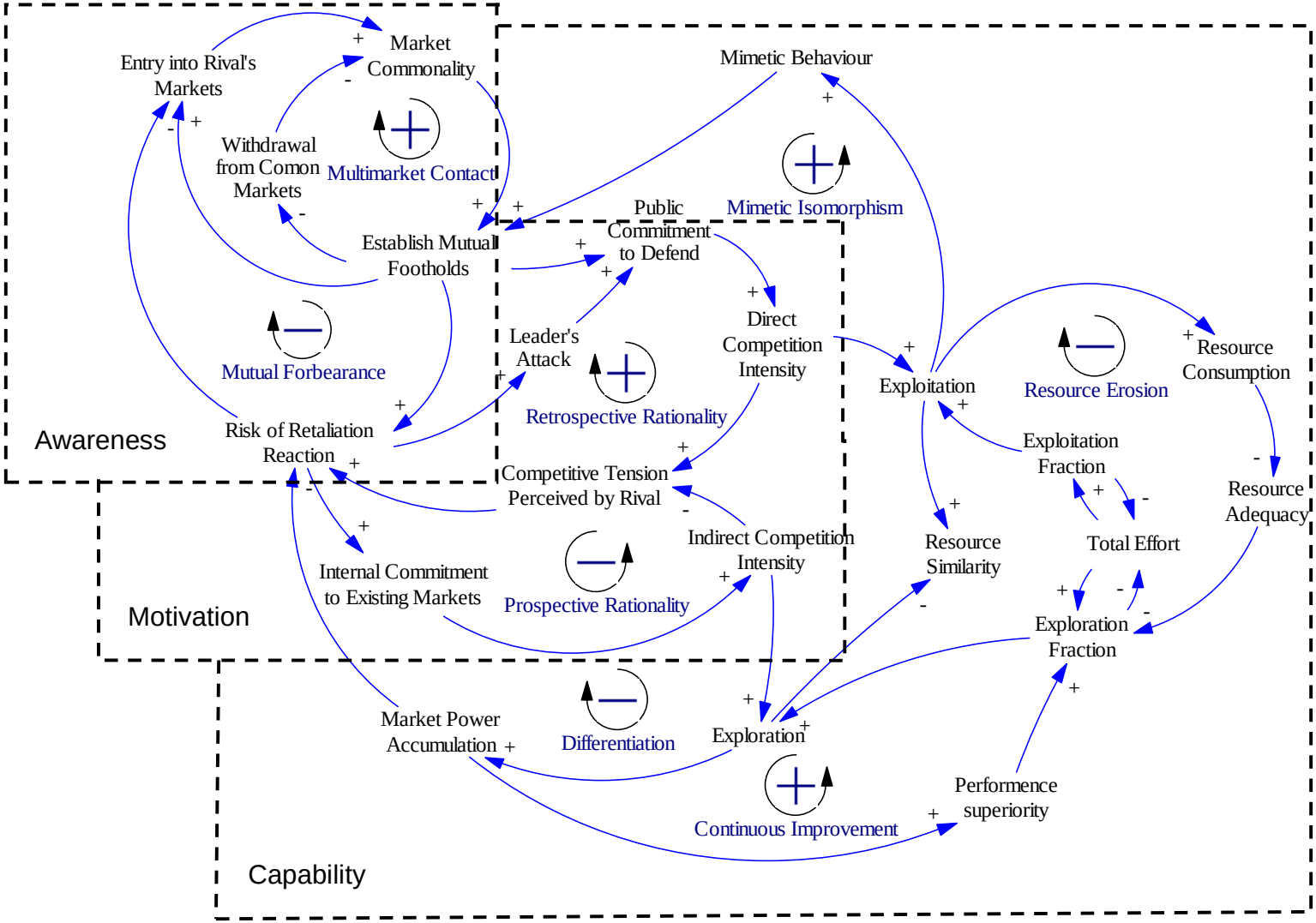
Drawing from escalation of commitment theory, one important driver of competitive interaction is the irreversibility of a course of action (Staw 1981). It is crucial for our study as the re/actions taken within the system of competitive process improvement always involve large investment, like implementing a TQM program (Repenning and Sterman 2002; Sterman et al. 1997). Such (re)actions will then form both "internal commitment" and "public commitment" simultaneously (Chen and MacMillan 1992; Chen et al. 2002; Staw 1981).

Internal commitment, *q*, is generated from economic costs associated with prior investment or sunk costs, political efforts associated with the need to be a determined and consistent leader, and organizational changes associated with structure inertia (Chen et al. 2002; Hannah and Freeman 1984; Whyte 1986). Such commitment will constrain action reversion once it has already been implemented. Public commitment, *p*, is generated from social and institutional pressures to protect the firm's reputation to the external world, which will strongly encourage firms to seek justification for previous actions that have been taken (Chen et al. 2002; Staw 1981). The different commitments attached to the (re)actions would result in different effects on the rivals' competitive tension. The construct "Competitive Tension, *H*," is affected by both the level of direct competition, *D*, and indirect competition, *N*. A direct head-on competition will greatly raise the tension between the opponents, and conservative actions of indirect competition will drop the tension. Formally:

$$(d / dt)\ H = D - N. \tag{6}$$

Process improvement could greatly contribute to the foundation of retaliation capability identified in the previous loops (Keating et al. 1999; Repenning and Sterman 2002). Thus, by incorporating with both public and internal commitments attached to the process improvement decisions, another two comparative loops are developed to reflect a desire as much to rectify past outcomes as to attain future ones (Staw 1981).

FIGURE 1
A Formal Model of System Dynamics for Competitive Process Improvement



Retrospective rationality reinforcing loop: "Retrospective rationality" indicates a form of forces for self-justification, under which decision makers are willing to seek to appear competent in 'previous' as opposed to 'future' actions (Staw 1981; Whyte 1986). Considering the follower's decisions in establishing mutual footholds, they may require top management approval and receive high amount of public attention (Chen et al. 2002; Gimeno and Woo 1996). Then, the follower may attach high public commitment to such actions. Once the leader takes reactions towards the follower (i.e. Leader's Attack, *A*), she will demonstrate high incentive to justify her past actions by escalating her commitment of resources (Chen et al. 2002; Staw 1981). Formally:

$$p = \ln\left(f + a_4\right) + A, \text{ where} \tag{7}$$

$$A = \begin{cases} a_5 \cdot r, & \text{if } x \le r \le y \\ 0, & \text{otherwise} \end{cases}, \text{ and} \tag{8}$$

a_4 (= 1 in the base case) is a constant to ensure that public commitment is positive even without any attack from the leader, and a_5 (= 0.6 in the base case) is the coefficient to reflect the leader's attack volume. It is noticeable that leader is expected to take actions within a given range of the retaliation risk. Because the retaliation capability is reciprocal, the range given between *x* and *y* reflects that attacks would only occur when the leader could perceive the risk from the follower (above *x*) as well as before it's too risky to take actions (below *y*).

Due to the high public commitment, the follower tends to decrease response delay and offer matching response to show her commitment of defending herself (Chen et al. 2002). This in turn will lead to direct competition between the rivals (Chen and MacMillan 1992; Smith et al. 1991), thus increase the competitive tension which may evoke the next action-reaction exchange. Formally:

$$D = \left(p \cdot H\right)/s, \tag{9}$$

where *s* is the respond speed to protect her reputation and defend the existing .

Prospect rationality balancing loop: Decision makers are "prospectively rational" if they are seeking to maximize future utility (Staw 1981; Whyte 1986). The increasing mutual footholds will bring higher risk of the leader's attack (Baum and Korn 1999; Gimeno and Woo 1996). This process is perceived as the demonstration of internal commitment at which the follower is cautious about her aggressive attack and more likely to concentrate on what she has already had. The strategic delay in relaxing the retaliation attack risks may provide opportunities to the follower to take prospective attitude in order to seek competency in the future (Rahman 1998). That is,

$$q = a_6 \cdot r, \tag{10}$$

where a_6 (= 0.8 in the base case) is the coefficient to reflect the follower's commitment to internal development. This internal concentration in turn will lead to indirect competition between the rivals due to the intentional delay (Chen and MacMillan 1992; Chen et al. 2002; Smith et al. 1991), thus decreasing the competitive tension which may eventually stabilize the interactions between the rivals:

$$N = (q \cdot H)/g\,, \tag{11}$$

where g is the respond delay due to the internal concentration on self-development.

Learning Strategies Diverge Competitive Tension

Studies show that organizations often experience sustained periods of improvement driven by both learning by doing (i.e. exploration) and knowledge transferred from others (i.e. exploitation) (Gupta et al. 2006; March 1991). Thus, another two comparable loops are developed to capture the impacts of different learning approaches on competitive tension.

Mimetic isomorphism reinforcing loop: Motivated by the outstanding performance of the leader, the follower will be greatly encouraged to engage in imitation if high market commonality and/or resource similarity are/is perceived (Knott 2003; Chen 1996). While the leader acts as the follower's benchmark in developing best practice, she is more likely to imitate him due to his easy observability and institutionalization (Anand et al. 2009; Haveman 1993; March 1991). In particular, when uncertainty is great the follower tends to follow the leader's processes so as to avoid eventually finding herself in a disadvantageous competitive position (Feldman and Pentland 2003; Tranfield and Smith 1988). Also she needs not to bear the disadvantages of being first to market (Anand et al. 2009; Lieberman and Montgomery 1988). According to the organizational ecology literature, first mover may suffer strong inertia that limits the ability to offer adaptive response in a changing environment (Hannan and Freeman 1984).

Therefore, given high direct competition between the rivals, the follower tends to adopt exploitation method to imitate the existing opportunities to build up her retaliation capability in a shorter time. All the exploitative activities are supported by the follower's level of 'Resource Similarity, *S*'. With more similar resources, the follower is more likely to completely imitate leader's operational process. The stock of resource similarity will be increased by a systematic exploitation of existing processes, *V*, and decreased by a continuous exploration of new opportunities, *O*:

$$(d/dt)\, S = V - O\,. \tag{12}$$

To sum up, all the significant benefits achieved from 'Mimic Behaviors, *m*,' would reinforce the follower's commitment to the continuous imitation of the current best practice, which will form structural inertia in learning (Hannah and Freeman 1984).

$$m = S \cdot u_i \tag{13}$$

where u_i reflects the effectiveness of exploitative activities.

In some circumstance, the mimetic isomorphic loops operate as vicious cycles. That is, the deterioration of the ability to completely imitate the leader's process will result in poor deterrent in the shared market, further leading to less able to show her public commitment to engaging direct competition.

Differentiation balancing loop: Sometimes, as discussed in the Prospective Rationality Reinforcing Loop, the follower may choose to adopt a long response delay towards the leader's reaction. Although imitation could bring certainty to the follower without taking much risk, pure imitation is unable to allow her to actively challenge the leader in terms of market share erosion

and/or dethronement (Ferrier et al. 1999). According to learning curve theory (Lieberman and Montgomery 1988), a pioneer can keep learning proprietary to generate substantial barriers for followers to imitate. Therefore, a follower may be more likely to operate in vicious mimetic isomorphic loops, and struggle the fundamental capability to defend herself.

It is important for the follower to run the differentiation loop to concentrate on her 'Internal Commitment to Existing Markets' to engage in 'Indirect Competition', which allows her to conduct explorative activities to develop her own unique routines and capability to improve her market power, l (Feldman 2000). The accumulated market strength then reduces the threat from retaliation attack. While maintaining the retaliation risk at an acceptable level, the self-invented routines may generate learning barriers for the leader to duplicate. Formally:

$$l = O \cdot v_i . \tag{14}$$

where v_i reflects the effectiveness of explorative activities.

Carrying Capability Constraints Continuous Imitation

While resource similarity provides a common basis for mimic actions, the accumulation of organizational routines to improve the existing process may have a long delay effect (Rahmandad et al. 2009; Repenning and Sterman 2002). It is because the resources an organization has in one period, at least in the short term, are 'sticky' to change; sometimes firms are to some degree stuck with what they have and may have to live with what they lack (Teece et al. 1997). Generally, the follower is expected to adjust internal tension between exploitation and exploration to achieve both survival and growth.

Resource erosion balancing loop: We need to recognize that few routines are 'stand-alone', which imitation can always be hindered. As a result, coherence may require that a change in one set of routines in one part of the firm (e.g. production) requires systemic changes in some other part throughout the organization (e.g. R&D), which may require massive resource consumption within the firm. Imitation takes time. Chang in routines always means change the meaning of the job process; hence, the structure of the organization is transformed (Feldman 2000). As a result, the necessary organizational capacity support is required to support such transformation. Specifically, the resource consumption and carrying capacity will be evaluated to support the successful implementation of process improvement (Fujimoto 1999). Actually, the imitation of best practice may be illusive. Formally:

$$V = \left(1 - z\right) D , \tag{15}$$

where z reflects the effort fraction invested in explorative activities. So, with limit carrying capability to support complete imitation, the follower needs to transfer her effort into exploring new opportunities.

Continuous improvement reinforcing loop: It is remarkable that although Toyota tried to adopt many practices and techniques from MPS, some of them were incomplete due to the historical imperatives and lack of absorption capacities (Fujimoto 1999; Cohen and Levinthal 1990). The famed JIT was largely a response to internal constraints of scarce space, high inventory costs, and input shortages (Fujimoto 1999). By concentrating on internal commitment, Toyota developed such system, which was ultimately applied to facilitate quality control (Nelson 1991).

Although the initial absorptive capability may be accumulated unintentionally, the associated economic benefits and the superior performance may reinforce the maintenance of such capability for future innovation (Cohen and Levinthal 1990). Therefore, it creates deviation from the existing best practice and greatly foster process improvement on a continuous basis. Formally:

$$O = z \cdot N . \tag{16}$$

According to the above casual mechanism, we conduct computer simulation experiments in the following part.

Simulation Experimentation

In this section, we rigorously examine the competitive dynamics between two competing processes during a ten-year period, and observe process evolvement patterns drove by the underlying dynamic system for further understanding the interrelationship between external and internal tensions.

We begin with a set of experiments showing how interplay of external and internal tensions produces possible three different outcomes for the follower's operational performance. Specifically, how different learning behaviors – proactive, reactive, and constant – of solving internal tension shape her tactics of taking (re)actions to deal with external tension which in turn determine her ability to survive and growth under competition? For clarity of analysis, tipping point between firm's survival and death is assumed to be decided by the stock value of competitive tension: A positive competitive tension indicates the existence of the follower; otherwise, a negative value indicates the termination of the firm.

Three Learning Approaches Lead to Different Operational Performance Outcomes

In competitive relationships, there are three possible performance outcomes: termination, survival without self-development, and continuous improvement. Three learning approaches are possible to result in those outcomes. They are *constant learning*, *reactive learning*, and *proactive learning approaches*, explained below. To highlight the differences between the three operational outcomes, Figures 2 to 4 display the evolvement of competitive tension and resource similarity over time. Simulation conditions are identical for the three situations except for the determination of exploration fraction, which reflects the follower's recognition of the strategic aspect of process improvement.

Constant learning approach: Figure 2 is an illustration of the operational performance under constant learning approach, where the follower takes a fixed distribution of effort towards exploration and exploitation regardless of the circumstance. That is, when the follower has sufficient resources to support the complete imitation of the leader's process, she would devote herself into exploitation (where exploration fraction is 0.1 out of 1); when she find the resources were inadequate, she would change to exploring activities immediately (where exploration fraction is 0.9 out of 1), without further consideration of external competitive tension. Thus, exploration effort is independent of competitive tension when employing this learning approach.

Given a low initial resource similarity value of 0.2, as illustrated at the top panel of Figure 2, the follower begins to commit to exploration from the fourth month. It is because the more similar resources the follower maintains the more carrying capacity she has to support

systematic imitation. Not surprisingly, due to the increasing exploration effort, the follower's resources become divergent to the leader. However, at Month 18, the competitive tension between the follower and the leader drops below zero, which indicates that the follower does no longer threaten the leader's market position (i.e. termination of the follower's process).

However, given a high initial resource similarity value of 0.8, as illustrated at the bottom panel of Figure 2, the follower is always investing in exploitative activities to imitate the leader's process. In this similar setting, the resource similarity continues to increase. The competitive tension, however, with an initial increase in the early stage, drops gradually at the end of the first year.

In summary, the constant learning approach in Figure 2 shows two important features of competitive process improvement. First, the neglect of external tension would lead to the follower's inability of adjusting her internal approach to fit a competitive environment, and eventually result in either termination of operational process or pure imitation without any self-development. Second, a continuous investment in exploitative activities would decrease the external tension in the long run, which is surprising. According to intuition, the greater exploitation effort the follower spends on learning, the more retaliation capability she develops to compete against the leader. Furthermore, it is expected to attract high risk of retaliation attack from the leader to protect his market share and reputation. Therefore, the competitive tension between the rivals is expected to be much higher than that derived from high exploration effort fraction. The Prospective Rationality Loop is the key to explain the counterintuitive results from the simulation. While the imitation increases the multiple footholds to show deterrent to the leader, which increases the public commitment to engage in direct competition, the imitation also increases the internal commitment indirectly due to the large investment, which would result in response delay and eventually reduce the level of competitive tension.

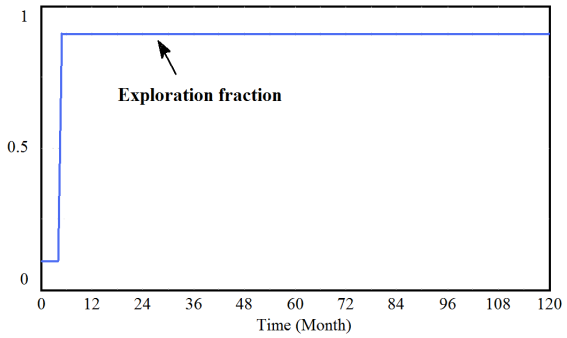
Reactive learning approach: Reactive learning approach is the way the follower takes to respond to external tension passively: Considering the current market strength and market commonality with the leader, the follower would have an evaluation of her competitive position; and, she tends to take it into account to determine the fraction of exploration effort instead of a fixed distribution. Thus under this approach, exploration effort is negatively related to resource adequacy and positively related to competitive tension.

The more similar resources the follower maintains, the more likely she adopts exploitation approach due to the availability and achievability of the superior operational process. However, the follower is also aware of the fact that only exploration could lead to a better performance than the leader. She will utilize the current market position to relax the direct exploitation pressure for short-term benefits, and have greater flexibility to invest in explorative activities. While taking the external competition into consideration, the follower is more willing to imitate the leader's operational process to sustain her current achievement in the competition without a longer-term orientation in self-development.

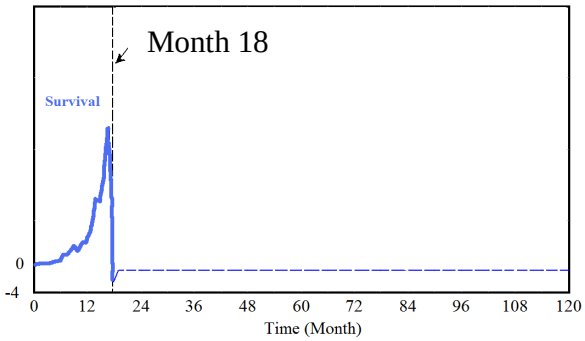
As illustrated in Figure 3, the follower first starts a competition with the leader in a low initial value of market commonality (0.2), market strength (0.1), and resource similarity (0.2). Therefore, she has to develop new routines to achieve better competitive position. When the initial competition is less intensive, the follower is more comfortable to invest in exploration activities in the first two years. However, the associated increase in operational performance is

FIGURE 2 Operational Performance under Constant Learning Approach

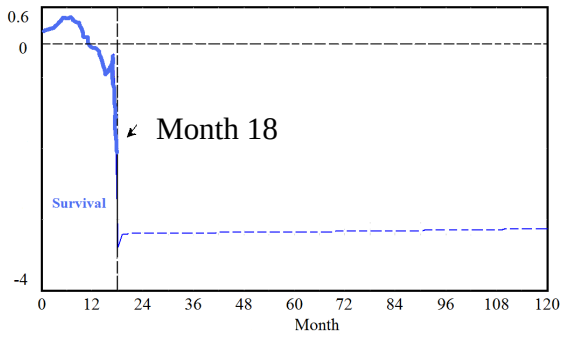
2a Exploration fraction (low initial value)



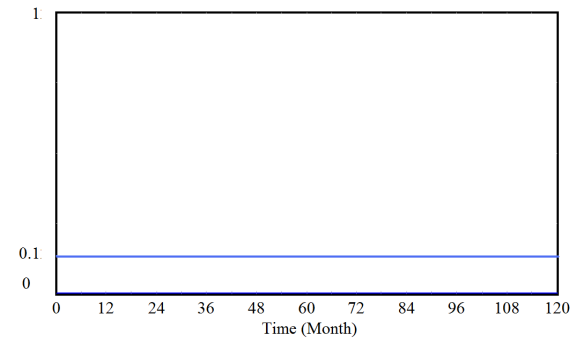
2b Competitive tension (low initial value)



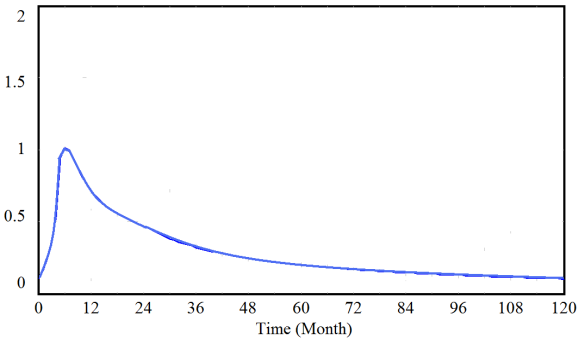
2c Resource similarity (low initial value)



2d Exploration fraction (high initial value)



2e Competitive tension (high initial value)



2f Resource similarity (high initial value)

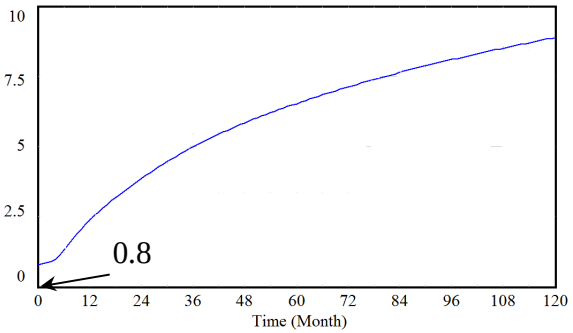
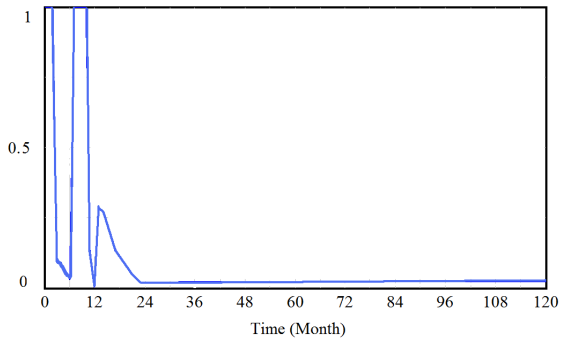
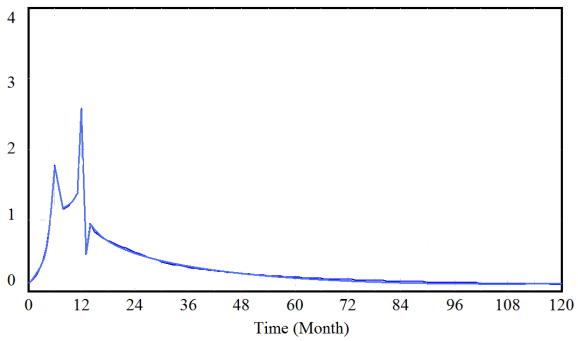


FIGURE 3 Operational Performance under Reactive Learning Approach

3a Exploration fraction



3b Competitive tension



3c Resource similarity

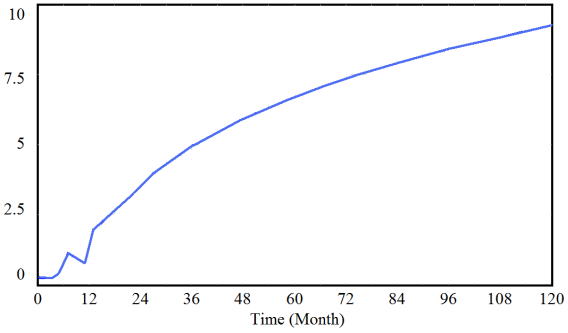
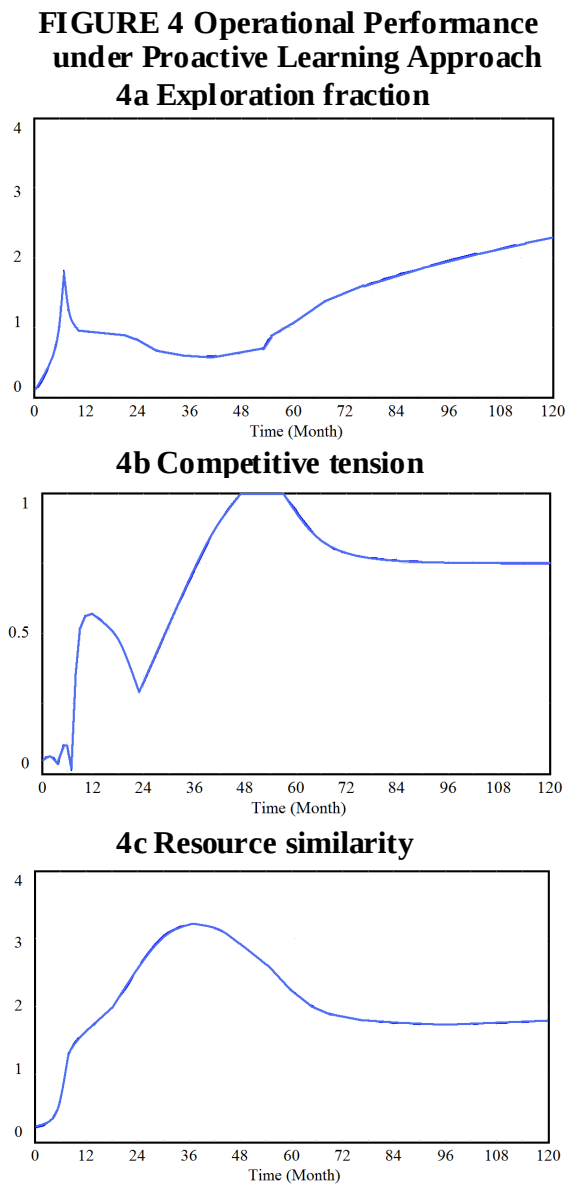


FIGURE 4 Operational Performance under Proactive Learning Approach



so significant that it sharply enhances the competitive tension, increasing strongly survival pressure to the follower due to the increase of the leader's attack. Ignorance of such pressure may eventually lead to the termination of the firm. Hence, rather than continuously sticking to exploration, the follower has to turn her attention to exploitation to achieve predictable short-term achievements to deal with the leader's attack. Therefore, after around two-year experimentation, the follower has to concentrate on imitate the leader's process to ensure her survival in the market. By drawing necessary attention to respond to the changing external tension, the follower is able to adjust herself to fit in with the responses of the leader, which facilitates the formation of inertia to adopt exploitation in the latter stage of competition.

In sum, the reactive learning approach in Figure 3 shows the results similar to those in the constant learning approach. The difference between these two approaches is only that the passive consideration to the external tension could help ensure the survival of the following firm, but still could not generate self-development for continuous improvement.

Proactive learning approach: Proactive learning approach is the way that the follower actively responds to external tension and takes initiative to balance short-term survive pressure and long-term growth pressure at the same time. It is consistent with our observation of Toyota's experiences in developing TPS against MPS. Under this approach, the follower tends to invest greater exploration efforts for future development even when there are adequate resources for complete imitation. That is, exploration effort is positively related to both resource adequacy and competitive tension.

As illustrated in Figure 4, the follower chooses to learn the leader's process by imitation first to attain certainty performance outcomes as does the other approaches. However, she tends to imitate the leader's process selectively, and integrates with the exploration effort to further develop firm-specific capability by considering both his and her own situations. So, the follower's resources are inclined to be gradually dissimilar to those of the leader in the long run.

Note that the competitive tension evolves in an increasing trend with a major decline in the earlier stage of competition. At the beginning of the competitive moves exchange, the tension

between the leader and follower is rising due to the increasing visibility of the follower in the competitive interdependent relationship. While the external tension reaches a high level for both firms, the follower may have to change her focus on differentiation strategies to distract the leader's attention in escalation of competition due to her subordinate role and less resource support to tolerate the enduring intensive pressure. This may in turn lead to the follower's commitment to explorative activities for enhancing her market position. With the support of increasing capabilities gained from such explorative activities, the follower is then able to engage in a fierce competition and may have an opportunity to take over the leader position in the long run; thus, the competitive tension eventually rises between the follower and the leader.

In summary, the proactive learning approach in Figure 4 shows another important feature of competitive process improvement: A continuous investment in explorative activities would increase the external tension in the long run. Similar to the findings in the constant learning approach, the increasing exploration efforts would lead to greater market strength, which would attract high risk of retaliation attack from the leader to defend his market position. The competitive tension between the rivals is eventually expected to be much higher.

Learning Effectiveness Impacts Internal and External Tension

As argued, it seems that the trade-off between exploration and exploitation drove by the external competitive tension is the key to decide the performance of operational processes. The determinant of exploitation inertia or exploration inertia is its effectiveness. As the two factors are exogenous in our model, a sensitivity analysis is required for further exploring the feedback of internal tension to external competitive tension.

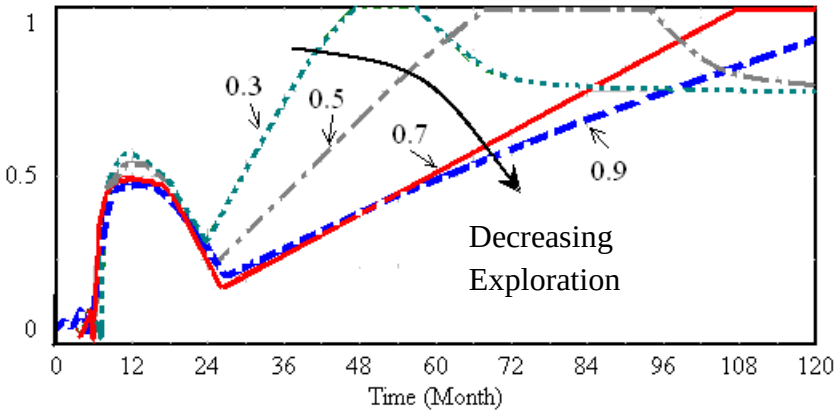
Exploitation effectiveness in our model reflects the learning barriers created by the leader to prevent complete imitation of the follower. Exploration effectiveness is mainly determined by the inherent capability in developing new ideas. From the perspective of competitive strategy (Porter, 1980), we are more interested in investigating the impact of exploitation effectiveness on the proactive learning approach mode.

As exploitation effectiveness increases, the effort spent on exploration is expected to decrease over time (see Figure 5a). The simulation result is consistent with our intuition about the follower's risk attitude. Although she finally recognizes the importance of developing firm-specific resources through exploration, there is a significant delay in committing to such activities due to the increasing exploitation effectiveness. Consequently, as illustrated in Figure 5b, organizational resources are then expected to become more similar to each other due to the preference of exploitation. As a result, the market strength loses along with the higher exploitation effectiveness (see Figure 5c). Additionally, the simulation results of competitive tension are consistent with the findings in constant learning approach and proactive learning approach (see Figure 5d). That is, at higher level of exploitation effectiveness, i.e. the best practice developed by the leader is of less causal ambiguity and quite easy to be imitated, the increased emphasis on mimic behaviors will attract high risk of retaliation attack from the leader to protect his market share and reputation. However, by taking account of internal commitment of actions, the competitive tension between the rivals becomes lower in the long run.

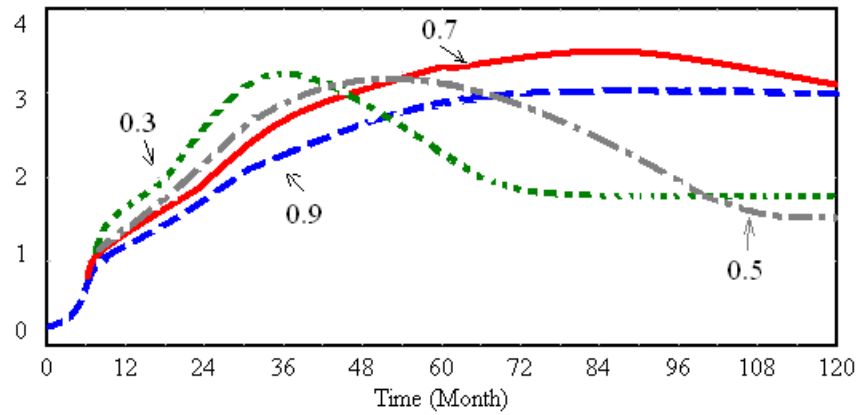
FIGURE 5

Internal Tension and External Tension for Various Exploitation Effectiveness

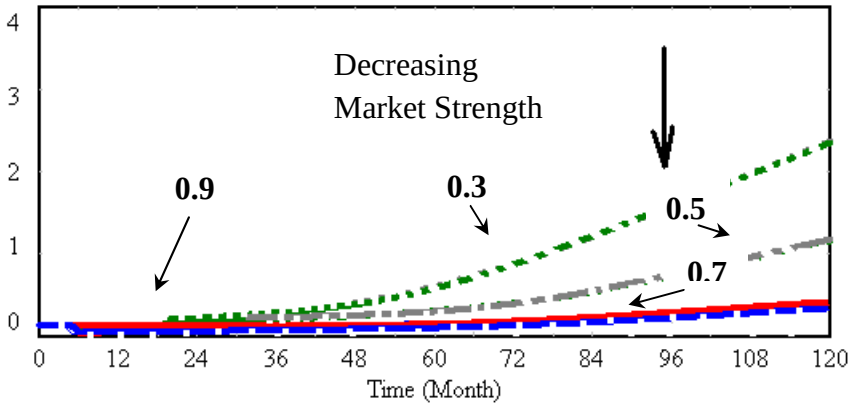
5a Exploration fraction for various exploitation effectiveness



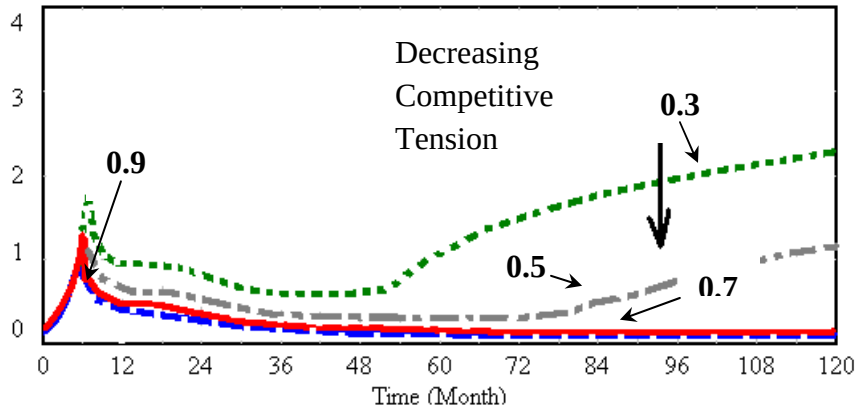
5b Resource Similarity for various exploitation effectiveness



5c Market Strength for various exploitation effectiveness

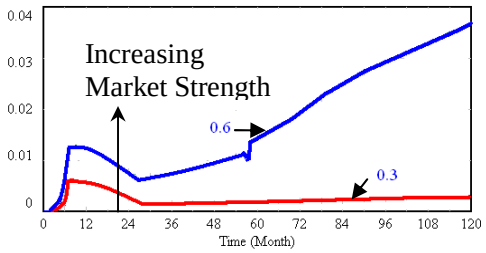


5d Competitive Tension for various exploitation effectiveness



The analysis raises the question of what level of barriers is optimal to prevent the effective imitation from the follower. As shown in Figure 5, while it is obvious that the increasing exploitation effectiveness may result in a lock-in effect of the follower's learning behaviors, the additional benefits are decreasing. This analysis does not consider the follower's inherent capability of self-exploration. By considering it, we find that given a level of exploitation effectiveness, the follower with a higher exploration effectiveness would still enhance her market strength (see Figure 6), which may greatly diminish the specified lock-in effect.

FIGURE 6 Market Strength for Various Exploration Effectiveness



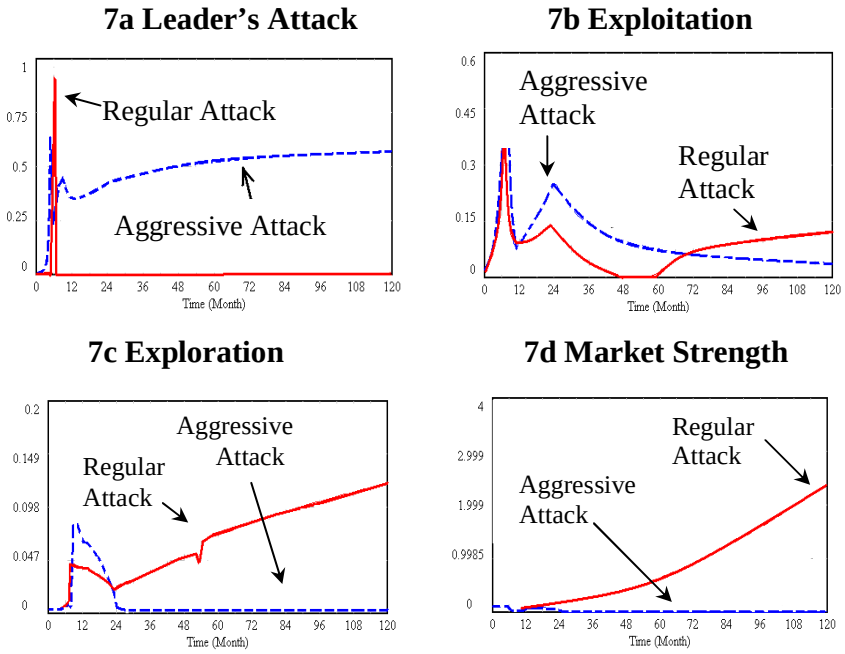
Leader's Initiative Frames His Attack Volume

The follower's ability to accumulate market strength and maintain sustained investment in exploration to achieve long-term development is largely influenced by the external tension. As the increasing market strength could enhance the market position, thus reduce the risk of retaliation attack from the leader. That is, the market strength provides the backup for the follower's to initiate attack to challenge the leader. However, it is important for the follower to accumulate a certain level of capabilities and market strength under a relaxed competitive environment without aggressive attack from the leader. Under the competition environment, the leader is expected to detect the follower's market strength over time and initiate necessary attack to avoid such growth.

In our simulation, we compared two different types of leader's initiative in attacking the follower. At one setting, the leader only takes regular attack when the retaliation risk is visible and acceptable. He does not take actions when the risk level is low due to the less visibility of the follower's market strength; and, he also withdraws his attack when the risk is high because of the deterrent from the follower. At the second setting, in addition to the regular attack, the leader also acts aggressively even at a low or a high retaliation risk level. Thus, he could actively identify the follower at her early development stage, thus effectively prevent the large increase of the follower's capability, and also show his public commitment on defending his leadership. The comparison between the two types of attack is remarkable in Figure 7.

In the simulation, we could observe that when the leader could identify the follower as his competitor and take continuous aggressive attack, it becomes much more difficult for the follower to invest in exploration as she always experiences the survival pressure before accumulating enough market strength to relax such threats. Therefore, the follower is more likely to spend more effort on a short-term focus of exploitation at the expense of a long-term focus of exploration.

FIGURE 7
Internal Tension for Various Leader's Attack



Discussion and Conclusion

Research on conditions and causal mechanisms that influence business process improvement under the effect of competition has been yet unexplored in the extant management research. Specifically, little is known about the boundary limitations of current best practice. More interestingly, under what conditions is new best practice likely to emerge. By re-conceptualizing process improvement as a dynamical system at the firm level, this research draws on thoughts in business processes improvement and competitive dynamics (CD) to develop 1) a formal model of SD for competitive process improvement and 2) a theoretical framework of competitive process improvement from the following perspectives.

Balancing Exploitation and Exploration to be Superior

The trade-off and/or ambidexterity between exploitation and exploration have been greatly investigated in organization theory (e.g. Gupta et al. 2006; Levitt and March 1988; Lin et al. 2007; March 1991). The dynamic capabilities generated from resource development are the key to achieve better performance under competition (e.g. Teece et al. 1997). Both exploiting exiting opportunities and exploring new opportunities could contribute to the emergence of dynamic capabilities. However, only the capabilities derived from exploration could contribute to the radical improvement of underlying processes.

If employing the proactive learning approach mode, the follower's (her) resources are inclined to be gradually similar to the leader's (his) at the initial stage due to a large investment in exploiting actions. This simulation outcome is consistent with our intuition that the follower tends to duplicate the leader's success through direct imitation of his routines and existing practices when all these tactics have been proven to be effective in the leader's operational process. The simulation result is consistent with our intuition about the follower's risk attitude,

too. That is, although the follower finally recognized the importance of developing firm-specific resources through exploration, there is a significant delay in committing to such activities due to the increasing exploitation effectiveness. Consequently, as long as the follower has adequate resource to support exploitative activities, she tends to choose exploitation to attain predictable benefits by imitating the leader's superior processes. This leads us to propose the following propositions.

Proposition 1a: In the early stage of competitive interactions, the more similar resource bundles as the leader, the more likely the follower has adequate resources to take exploitative activities, all else being equal.

Proposition 1b: The more benefits attained from exploiting the existing opportunities, the more likely the follower conducts exploitation over exploration, all else being equal.

In our simulation, after an intense exploitation effort spent in the first few years, the follower is more likely to face the constraints of limited carrying capability to support the complete imitation of leader's entire system. It is mainly because all the routines within an operational system are inherently integrated with each other. A change in one routine can only yield desired outcome when the follower could take the consideration of all the relevant routines which requires massive investment to support the continuous changes (Feldman 2000; Feldman and Pentland 2003). Therefore, the follower might be forced to switch to search new opportunities by herself to sustain the growth. Additionally, although pure imitation can be still useful to build similar resource bundles as the leader with lower risks, the benefits obtained from exploration in developing firm-specific capability is still attractive for the follower to achieve higher operational performance (March 1981). Therefore, the inertia of adopting exploration was formed to influence the internal tension between the two resource development methods (Hannah and Freeman 1984). Formally:

Proposition 2a: In the later stage of competitive interactions, the less similar to the leader's resources bundles, the more likely the follower conducts exploration over exploitation, all else being equal.

Proposition 2b: The more benefits attained from exploring new opportunities, the more likely the follower conducts exploration over exploitation, all else being equal.

The notion of carrying capacity is consistent with our argument about proactive learning under competition. The simulation results suggest that since the follower has the accurate estimation on the consumption of organizational resources for exploitation, she thus needs to commit to investigate alternative processes at early stage when massive resource consumption on exploitation is needed. Those explorative actions were supposed to help the firm generate and accumulate absorptive capability to sustain continuous improvement in the future. Formally:

Proposition 3: In the context of competitive environment, the more resources it takes to conduct complete imitation of the leader's operational processes, the earlier the follower shall invest in explorative activities, all else being equal.

External Tension Drives Internal Tension to Achieve Long-Term Sustainability

The literature on exploration and innovation has focused on balancing internal tension that helps us better understand the innovation-related issues but, as argued by Anand, Mesquita, and Vassolo (2009), should also be complemented by an equally important assessment of external

factor such as competition. After all, the success or failure of a firm's strategies depends fundamentally on their interaction with competitors (Baum and Korn 1999).

Indeed, the degree of competitive tension (i.e. external tension) is an important driver of determining either the short-term or long-term orientation for survival and development. If the follower takes a short-run focus of reactive learning approach without considering a broad systematic picture in taking (re)actions, she can concentrate only on relaxing immediate pressure for survival in the competition. Our simulation results demonstrate the balance between exploitation and exploration (i.e. exploration fraction in the model) is influenced by external tension and competitive moves of opponents. Three different types of learning approaches (i.e. constant, reactive, and proactive) clearly illustrate the follower's attitudes towards the integration between external and internal tensions, which lead to significant differences in operational performance. Formally:

> *Proposition 4: In the context of competitive environment, the less awareness to incorporate external competitive tension into internal learning processes, the less likely the follower could generate innovative operational processes, all else being equal.*

Adding Perception Bias to the Leader's Interpretation of the Follower's Actions

CD in the strategy literature is a useful lens to analyze the evolvement of operational processes from a dyad action-reaction perspective. By taking competitors' responses into account, we could further explore the interplay between external drivers and internal resource development decisions. CD researchers tend to adopt the structure content analysis method to provide empirical support for their competitor analysis (e.g. Chen and Hambrick 1995; Chen and MacMillan 1992). This method could greatly capture the one-round interaction between one action and the corresponding reaction; however, it has limitations in studying the continuous pair-wised interactions. Therefore, the adoption of SD modeling could provide a better understanding about the enduring effects of one action on multiple exchanges of moves in a long period. In particular, we found quite surprising simulation outcomes about the impact of internal learning approaches on external competitive tension.

Initially, we expected that a short-term focus (i.e. exploitation-dominant learning) within the firm shall result in an increasing external competitive tension, as the increasing emphasis on mimic behaviors would attract higher public commitment of the leader to defend his market position. And a long-term focus (i.e. exploration-dominant learning) shall lead to a decreasing competitive tension when the response delay and exploration uncertainty would distract the leader's attention to initiate attacks. However, the simulation indicates quite the opposite results.

One possible explanation is the internal commitment attached to the learning activities as discussed in the previous section. All the actions involve both public and internal commitments (Chen, et al. 2002). Take imitating the leader's process as an example. While public commitment attached to exploitation was sufficiently high to motive the firm to react quickly and aggressively, it still needs to take the account of internal investment that has already occurred. In particular, for the case of process improvement, the massive resource requirement would significantly delay its reaction towards the other firm. When such internal commitment is large enough, it could hold back the intensity of competitive tension in the long run. In terms of exploration, while it is derived from the high commitment to the existing investment and adopted under the internal constraints, the firm objective is still to compete with the leader for rent generation; thus, the

public commitment to engaging in direct competition emerges as long as the positive outcomes was achieved through exploration.

Proposition 5a: In the context of competitive environment, a concentration on exploration tends to result in higher competitive tension, all else being equal.

Proposition 5b: In the context of competitive environment, a concentration on exploitation tends to result in lower competitive tension, all else being equal.

In addition to the retrospective and prospective perspectives of (re)actions, the leader's misperception of the follower's learning activities may also play an important role in the counterintuitive results. According to Levitt and March (1988), routine-based conceptions of learning are stored within routines retrieved through mechanisms of attention within a memory structure. Such mechanisms could not only record the history but also shape the perception towards the future. However, one firm may record the interaction experiences selectively, leading to the commitment of availability bias (Henderson and Cool 2003). For example, under aggressive exploitative activities, the follower is then perceived as an imitator and reactor towards the current best practice. In this case, the leader tends to predict the follower's next actions based on an interpretation of the follower's recent imitation activities. Such availability bias committed by the leader will mislead the measurement of competitive tension. Formally:

Proposition 6: The impact of internal learning approach on the external competitive tension is moderated by the competitor's availability bias, all else being equal.

Leader's Initiative and Asymmetric Awareness Shape Follower's Learning Pattern

The leader could influence the learning behavior of the follower in two ways. First is to build learning barriers to prevent her effective imitation of the current operational practices. Second is to utilize his superior market position to embrace intensive competitive tension to raise the survival pressure for the follower.

In terms of learning barriers, number of studies have emphasized on the importance of isolating mechanism (e.g. Knott 2003). Explicit process with less ambiguity will generate quite low learning barriers; thus, it will attract more imitation activities from the follower (Haveman 1993). They argued that tacitness and causal ambiguity are important to avoid the diffusion of the successful practices of the leader. However, our simulation results show that the less learning barriers could create the lock-in effect for the follower to stick at exploiting the existing operational process, which could effectively restrain the exploration fraction for being innovative. There is a conditional factor linked to this lock-in effect, the exploration effectiveness of the follower. The ability to create successful outcomes from self-exploration could ensure both effective exploitation and exploration. Formally:

Proposition 7: In the context of competitive environment, the more explicit of the best practice, the more likely the follower will allocate more resources to commit to exploitative activities, all else being equal. In other words, the exploitation effort is moderated by the enhancement of self exploration effectiveness, all else being equal.

The disruptive innovation literature (Christensen and Bower 1996) suggests that most incumbent could fail their attempts to generate innovative modification of current best practices. While their failure could be attributed to the lack of exploration effort, the external tension also plays a vital role. Because the retaliation capability derived from the innovative modification is reciprocal, the leader is expected to take actions before it is too risky to make the attack upon the

follower's substantial accumulation of market power (Gimeno and Woo 1996). Resource accumulation takes time. For protecting his market position, the leader needs to detect the follower's market strength and initiate necessary attack in order to avoid the overwhelming increase of the follower's capability. When the leader tends to initiate an early (attack timing) and a continuous (attack volume) attack based on an early identification of the potential rivals, it is much more difficult for the follower to invest in exploration when she constantly experiences the survival pressure before accumulating enough market strength to relax such threats. Formally:

Proposition 8a: In the context of competitive environment, the earlier the leader initiates the attack towards the follower's innovative modification, the more likely the follower has to focus on exploitation, all else being equal.

Proposition 8b: In the context of competitive environment, the stronger volume the leader attacks the follower's innovative modification, the more likely the follower has to focus on exploitation, all else being equal.

Limitation and Future Research

Given the interacting constructs and relationships in the model, there is more than one way to analyze the best practice evolvement in industry. We does not argue that our framework provides a complete representation of business process improvement but, rather, that an action-reaction perspective on external tension and the associated interaction with internal tension could be sufficiently realistic and informative to provide insights about theory. By employing CD constructs and framework, we have articulated the mechanisms for further empirical exploration and further theory development. To the best of our knowledge, there are two possible ways to conduct empirical research on our proposed model. Firstly, structure content analysis could be employed to generate a statistical analysis of key predictors of the important role of action-response between competing organizations across a set of longitudinal data (see Chen et al. 2002). In addition to this, discrete choice modeling could be adopted to design choice experimentation for examining how business processes are improved within a competitive environment while longitudinal data are unavailable (Louviere et al. 2000).

The current study is mainly grounded on the development of TPS and its interaction with traditional MPS. Future research can conduct similar analysis on other sectors, such as service industry to investigate the generalizability of our research findings. Finally, in the framework construction, we have recognized organizational routine as the fundamental level of our analysis. In further studies, it is possible to distinguish different types of routines, such as operating routine and search routine, as suggested by Nelson and Winter (1982) and Feldman and Pentland (2003).

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