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The "Third Hand": IT-Enabled Competitive Advantage in Turbulence Through Improvisational Capabilities

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Organizations are increasingly engaged in competitive dynamics that are enabled or induced by information technology (IT). A key competitive dynamics question for many organizations is how to build a competitive advantage in turbulence with digital IT systems. The literature has focused mostly on developing and exercising dynamic capabilities for *planned* reconfiguration of existing operational capabilities in fairly stable environments with patterned "waves," but this may not always be possible, or even appropriate, in highly turbulent environments with unexpected "storms." We introduce *improvisational capabilities* as an alternative means for managing highly turbulent environments; we define this as the ability to spontaneously reconfigure existing resources to build new operational capabilities to address urgent, unpredictable, and novel environmental situations. In contrast to the planned role of dynamic and operational capabilities and the ambidexterity that they jointly offer, improvisational capabilities are proposed to operate distinctly as a "third hand" that facilitates reconfiguration and change in highly turbulent environments.

First, the paper develops the notion of improvisational capabilities and articulates the key differences between the two "reconfiguration"—improvisational and dynamic—capabilities. Second, the paper compares the relative effects of improvisational and dynamic capabilities in the context of new product development in different levels of environmental turbulence. Third, the paper shows how IT-leveraging capability in new product development is decomposed into its three digital IT systems: project and resource management systems, organizational memory systems (OMS), and cooperative work systems—and how each of these IT systems enhances improvisational capabilities, an effect that is accentuated in highly turbulent environments.

The results show that although dynamic capabilities are the primary predictor of competitive advantage in *moderately* turbulent environments, improvisational capabilities fully dominate in *highly* turbulent environments. Besides discriminant validity, the distinction between improvisational and dynamic capabilities is evidenced by the differential effects of IT-leveraging capability on improvisational and dynamic capabilities. The results show that the more the IT-leveraging capability is catered toward managing resources (through project and resource management systems) and team collaboration (through cooperative work systems) rather than relying on past knowledge and procedures (through organizational memory systems), the more it is positively associated with improvisational capabilities, particularly in more turbulent environments.

The paper draws implications for how different IT systems can influence improvisational capabilities and competitive advantage in turbulent environments, thereby enhancing our understanding of the role of IT systems on reconfiguration capabilities. The paper discusses the theoretical and practical implications of building and exercising the "third hand" of improvisational capabilities for IT-enabled competitive dynamics in turbulence.

Key words: improvisation; improvisational capabilities; dynamic capabilities; environmental turbulence; digital systems; IT-leveraging capability; new product development; competitive advantage; competitive dynamics
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1. Digital Competition in Turbulent Environments

Organizations are increasingly engaging in competitive dynamics that are enabled or induced by information technology (IT), and empirical studies have shown that competitive advantage may be achieved with the effective leveraging of IT (e.g., Chi et al. 2007, 2008b). As the environment becomes increasingly more turbulent, organizations have sought IT to help them become nimble and responsive to environmental changes and competitive actions. Competitive advantage in hypercompetitive environments is largely based on undertaking reconfiguration better, faster, and more efficiently than the competition (D'Aveni 1994). Information systems (IS) researchers have thus devoted much attention in studying how IT can facilitate reconfiguration by enhancing agility and dynamic capabilities (e.g., Desouza 2007, Houghton et al. 2004, Pavlou and El Sawy 2006, Sambamurthy et al. 2003). Similarly, much research attention has been recently directed at agile IT systems (Newell et al. 2007). However, although there is always a call to be flexible, agile, and nimble, it is less obvious how to specify the exact capabilities that organizations must develop and exercise with the aid of IT to address turbulent environments.

Part of the difficulty arises from the conceptual and operational ambiguity of concepts of "strategic flexibility" in the strategy literature. Bahrami and Evans (2005) acknowledge that strategic flexibility has bloated into a constellation of concepts, such as adaptability, agility, resilience, robustness, versatility, and absorption. Several of these concepts arose mainly as prescriptions for practice without formal theoretical conceptualization. To help organizations address different types of environmental turbulence, we theorize and prescribe specific capabilities that organizations can build and exercise with the aid of IT to engage in digital competition.

Building on the emerging literature on the "science of competitiveness" (Chi et al. 2008b), we seek to propose specific capabilities that organizations could develop and exercise with the aid of IT to address diverse types of turbulent environments. Turbulence describes the conditions of unpredictability in the environment because of rapid changes in customer needs, emerging technologies, and competitive actions. As suggested by Holsapple and Jin (2007), environmental turbulence may be manifested as either "waves," which are roughly predictable in their pattern, or "storms," which are rapid, have a strong impact, and occur unexpectedly. To help facilitate digital competition in turbulent environments, we seek to identify, theorize, operationalize, and empirically test specific capabilities that could be most suitable for these two types of turbulence.

Stemming from the resource-based view of strategic management, dynamic capabilities were proposed and conceptualized as specific capabilities by which organizations reconfigure existing operational capabilities into new ones to better match the environment (Teece et al. 1997, Eisenhardt and Martin 2000, Teece 2007). Dynamic capabilities have a positive role in competitive advantage in environments with relatively predictable patterns of change (Eisenhardt and Martin 2000), but they may not be appropriate for reconfiguring existing operational capabilities in stormy environments with unpredictable change (Winter 2003). Also, dynamic capabilities may not be possible to exercise in unexpected events, as they require prior planning, or they may be too costly to build and maintain in anticipation of unexpected changes. Also, limited planned preparations are possible in anticipation of surprises (El Sawy and Evans 1985). Therefore, organizations in environments with unpredictable patterns of fast change must reconfigure with alternative capabilities that require less planning and that can better address rapid, unpredictable, and novel events.

Hence, we introduce improvisational capabilities as an alternative means for reconfiguration in turbulence. Improvisational capabilities are defined as the ability to spontaneously reconfigure existing resources to build new operational capabilities to address urgent, unpredictable, and novel environmental situations. In contrast to dynamic capabilities that are best suited for environments with predictable patterns of change (Winter 2003) ("waves"), improvisational capabilities are best suited when the environment becomes highly turbulent ("storms"), past procedures offer little or no guidance, and spontaneity in identifying novel configurations is preferred. Despite their spontaneous and emergent nature, improvisational capabilities are not ad hoc or coincidental—they are conceptualized as collective, repeated, and purposeful capabilities that can be enhanced with practice. Also, although improvisation often has a negative connotation by implying lack of formal planning, it may be valuable when the environment introduces conditions in which sense-making collapses (Weick 1993), and improvisation may result in positive outcomes. The most vivid example of improvisation is the recent forced landing of a U.S. Airways flight into the icy Hudson river when both engines were disabled by a flock of birds. Without the luxury of formal planning or the ability to rely on existing procedures and models, the pilot had to improvise to address this novel condition, banking on his experience and skills, and decided literally "on-the-fly" to land the 150-passenger jet in the river, thus saving everyone, including people on the ground. Thus, when the turbulent environment brought an urgent, unpredictable, and novel situation, improvisational capabilities kicked in and rendered a positive outcome.

To more vividly illustrate how improvisational capabilities act differently from planned dynamic capabilities, we herein refer to improvisational capabilities as the "third hand." From Adam's Smith seminal "invisible hand," it has been acceptable to use physiological analogies when attempting to illustrate organizational phenomena. The "ambidextrous" organization (that can use both "hands" well) has been used in the organizational theory (e.g., Gibson and Birkinshaw 2004) and in IS strategy(Im and Rai 2008) literatures to denote how an organization is able to simultaneously conduct two seemingly competing capabilities. The interplay between dynamic and operational capabilities has been portrayed as another instance of ambidexterity (Pavlou and El Sawy 2006). Improvisational capabilities are proposed as a "third hand" to help organizations attain and retain competitiveness in turbulence. It remains to be empirically seen whether the third hand of improvisation capabilities acts as an ally or an antagonist to dynamic capabilities when reconfiguring operational capabilities in turbulent environments.

Because IT has been proposed as a key enabler of organizational capabilities (Mata et al. 1995), we examine the role of IT-leveraging capability (Pavlou and El Sawy 2006) on improvisational capabilities. By testing the effect of IT systems on both improvisational and dynamic capabilities, this study sheds light on the process by which digital IT systems help build a competitive advantage in turbulent environments. In doing so, it aims to inform the emerging science of competitiveness in terms of how IT can build a competitive advantage in turbulence, when it is characterized by both predictable "waves" and unexpected "storms" (Holsapple and Jin 2007). Besides, it adds to the emerging literature on how IT systems can be designed to support improvisation (Mendonça 2007).

The paper makes three main contributions. First, it introduces the notion of *improvisational capabilities* as a unique mechanism for accomplishing reconfiguration of operational capabilities in highly turbulent environments. It also distinguishes between dynamic and improvisational capabilities as two distinct means for reconfiguration and building a competitive advantage in turbulence. Second, the study shows that the moderating role of environmental turbulence on the effects of improvisational and dynamic capabilities on competitive advantage is complex, and the competitive potential of dynamic capabilities diminishes in highly turbulent environments and gives way to improvisational capabilities; the opposite effect is shown in moderately turbulent environments. Third, it looks more closely inside the "black box" of IT and shows how different types of IT systems are associated differently with improvisational and dynamic capabilities. Specifically, IT-leveraging capability is decomposed into its three basic IT systems (project and resource management systems [PRMS], organizational memory systems [OMS], and cooperative work systems [CWS]) to examine their relative impact on improvisational and dynamic capabilities, showing that IT systems have a differential effect on these capabilities.

The rest of the paper is organized as follows: Section 2 reviews the theoretical foundations of the study of IT-enabled competitive advantage in turbulent environments. Section 3 introduces the conceptualization of improvisational capabilities, discusses their distinction from dynamic capabilities, and offers hypotheses on the outcomes (competitive advantage) and antecedents (effective use of IT systems) of improvisational capabilities in different levels of turbulence. Section 4 describes the research design, and §5 presents the data analysis and results. Section 6 discusses the study's contributions and implications for theory and practice.

2. Review of Theoretical Foundations in New Product Development

In this study, we have chosen the context of new product development (NPD) with the "NPD work unit" (group or organization) as the unit of analysis for several reasons: first, NPD is a strategic function by which organizations can build a competitive advantage with competitive new products (Clark and Fujimoto 1991). NPD is defined as the set of activities that start with "the perception of a market opportunity and end in the production, sales, and delivery of a product" (Ulrich and Eppinger 1995, p. 2). Second, reconfiguration capabilities are particularly valuable in NPD to reconfigure outdated operational capabilities into new ones that better match the environment. Third, the information-intensive nature NPD makes it likely to be supported by digital IT systems (Nambisan 2003). Finally, environmental turbulence is prevalent in NPD with rapidly changing customer needs, frequent technological breakthroughs, and unpredictable new product introductions by aggressive competitors. Thus, NPD is an ideal context for examining how to address turbulent environments (Eisenhardt and Martin 2000).

Environmental turbulence describes the general conditions of unpredictability because of changes in customer needs, new technologies, and strategic moves by aggressive competitors (D'Aveni 1994).[1] These changes may occur either in the external (e.g., market needs, competitor strategies, disruptive technologies)[2] or the internal environment (e.g., internal crises) (Mendelson 2000). These changes are manifested as either "waves," which are roughly predictable in their pattern, or "storms," which are sudden and occur unexpectedly (Holsapple and Jin 2007). The distinction between waves and storms is also noted by Eisenhardt and Martin (2000), who term *moderately dynamic markets* as relatively predictable environments with expected patterns (waves), and "high-velocity markets" as those with unpredictable and nonlinear changes (storms).

Environmental turbulence is an important element of NPD because new products must address changes in customer needs, emerging technologies, and competitive new products introduced by aggressive competitors. Environmental turbulence in NPD consists of two primary sources (Jap 2001): first, *market turbulence*, which denotes changes in consumer needs, and competitors' new products; second, *technological turbulence*, which denotes changes in new technologies and technological breakthroughs. These changes, which could be in the form of waves or storms, reflect the degree of environmental turbulence experienced by NPD work units.

Dynamic capabilities were proposed as major means for managing in moderately turbulent environments (Eisenhardt and Martin 2000). Dynamic capabilities are defined as "the ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece et al. 1997, p. 517).[3] Dynamic capabilities are heterogeneously distributed across organizations, and their complex nature makes them a source of competitive advantage (Teece et al. 1997). Applied to NPD (Figure 1), dynamic capabilities[4] were shown to help

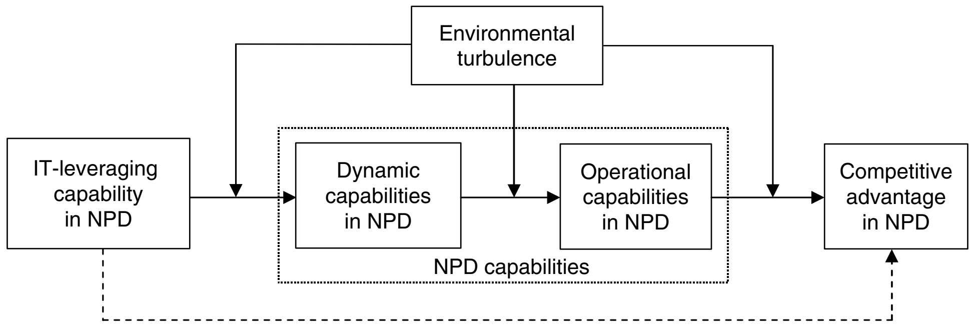
[1] D'Aveni (1994) describes competitive advantage in turbulent environments as short lived because organizations continuously engage in a series of competitive actions to disrupt their competitors' continuous competitive actions. D'Aveni argues that a larger number and variety of new competitive actions is likely to build a competitive advantage.

[2] Disruptive technologies, such as "combinatorial innovations" (Varian 2009) are based on rapid on-the-fly recombinations of software and IT tools to create new products (such as software mash-ups).

[3] There are obviously several definitions of dynamic capabilities. We herein adopt the definition from the seminal work of Teece et al. (1997), which is generally regarded as the original definition of dynamic capabilities.

[4] Pavlou and El Sawy (2006) proposed a second-order model to operationalize dynamic capabilities in NPD as a set of interrelated yet distinct factors. First, *sensing capability* (or market orientation) is the ability to sense the environment to assess market needs and identify new opportunities for reconfiguring operational capabilities. Second, *learning capability* (or absorptive capacity) is the ability to revamp existing operational capabilities by acquiring,

Figure 1 The Mediated Effect of IT-Leveraging Capability on Competitive Advantage in NPD



Note. Adapted from Pavlou and El Sawy (2006).

NPD work units reconfigure their operational capabilities into superior new ones that better matched the environment (Pavlou and El Sawy 2006), thus demonstrating the positive effect of dynamic capabilities on competitive advantage in NPD through operational capabilities. Competitive advantage in NPD is a combination of process efficiency (time and cost) and product effectiveness (high-quality new products), and the NPD literature views *operational capabilities*[5]—the ability to build quality new products by efficiently undertaking substantive day-to-day activities—as the direct basis for new products and a competitive advantage in NPD (Clark and Fujimoto 1991). In contrast, outdated operational capabilities (or "rigidities") (Leonard-Barton 1992) result in inferior new products. Dynamic and operational capabilities are distinct because dynamic capabilities reconfigure existing operational capabilities into new ones (Eisenhardt and Martin 2000). The positive role of dynamic capabilities on operational capabilities is reinforced by environmental turbulence. As strategic options (Kogut and Zander 1992), dynamic capabilities give the ability to pursue new opportunities, which are more likely to materialize in turbulent environments. However, turbulent environments attenuate the direct effect of operational capabilities on competitive advantage by disrupting their continuity and efficiency (Figure 1).

Figure 1 is based on the work of Pavlou and El Sawy (2006), whose primary focus was on delineating the process by which IT-leveraging capability builds a competitive advantage in NPD through two mediating NPD capabilities (dynamic capabilities and operational capabilities). *IT-leveraging capability in NPD* is defined as the ability to effectively use IT functionalities to support IT-enabled NPD activities. IT-leveraging capability in NPD is viewed as a three-dimensional construct that captures how three IT functionalities are leveraged (or effectively used):[6] PRMS, OMS,[7] and CWS. First, PRMS are IT tools for resource allocation, task assignment, and scheduling (Rangaswamy and Lilien 1997). Second, OMS, such as knowledge coding, directories, and retrieval

assimilating, transforming, and exploiting knowledge and developing new knowledge and skills. Third, *integrating capability* (or collective mind) captures the effectiveness in embedding the new knowledge into the reconfigured operational capabilities by creating a collective sense-making with heedful contribution, representation, and interrelation. Fourth, *coordinating capability* is the ability to orchestrate and deploy reconfigured capabilities by managing dependencies among resources and tasks.

[5] The three most important operational capabilities in NPD are *customer, technical*, and *managerial* (Danneels 2002). Customer capability is the ability to execute customer sales programs by understanding customer needs. Technical capability reflects the ability in R&D, product engineering, product design, and manufacturing. Managerial capability is the ability to design incentives, monitor progress, and manage NPD activities.

[6] These three systems are the common systems used in NPD (Nambisan 2003). Although organizations have other systems (e.g., enterprise resource planning, supply chain management) that are used in other functions or across the organization, we focus on IT systems specific to NPD.

[7] We thank the Special Issue Editor Clyde Holsapple for suggesting the term "organizational memory systems" to refer to this category of systems. Our previous work (Pavlou and El Sawy 2006) used "knowledge management systems," but OMS is a more appropriate, illustrative term that stresses the specific IT systems that help bring past knowledge to bear.

IT functionalities, support the acquisition, assimilation, transformation, and exploitation of knowledge practices (Stein and Zwass 1995). Third, CWS, such as conveyance, presentation, and convergence systems, support real-time communication and group collaboration (Wheeler et al. 1999). Thus, IT-leveraging capability in NPD, formed by these three IT systems, reflects how effectively these IT systems are used.

IT-leveraging capability has a direct positive effect on dynamic capabilities because these three IT systems enhance the ability of NPD work units to sense the environment, enhance learning, integrate resources, and coordinate activities (Pavlou and El Sawy 2006). First, OMS support the processing and sharing of information (Tippins and Sohi 2003), thus enhancing the ability to sense the environment. Second, by facilitating the acquisition, interpretation, assimilation, transformation, and utilization of knowledge, OMS enhance the learning capability of NPD work units. Third, PRMS help manage resources and tasks and synchronize activities, thus enhancing the coordination capability of NPD work units. Fourth, CWS help integrate patterns of interaction of NPD work units by enhancing communication, thus enhancing their integration capability (or collective mind). Finally, in turbulent environments, the positive role of IT-leveraging capability in dynamic capabilities is more pronounced because turbulence stresses the emphasis on real-time information and knowledge flows.

3. Conceptual Development

3.1. Conceptualization of Improvisational Capabilities

3.1.1. Improvisation. Improvisation takes place when there is not enough time for formal planning, when existing plans do not apply to novel conditions (Crossan 1998), and when the time gap between planning and execution converges (Moorman and Miner 1998a).[8] Improvisation occurs for many reasons (Cunha et al. 1999), such as when novel events cannot be addressed with existing operational capabilities, when there is not enough time or it is too costly to engage in formal planning, when there is a need to act outside formal plans to cope with novel situations, and also when there is a "time pressure to solve problems and address opportunities quickly" (Miner et al. 2001, p. 329). Mendonça (2007) cites multiple instances when improvisation may be needed. Besides urgently reacting to novel events and environmental surprises, improvisation also occurs because of an intentional decision to forego formal planning. Improvisation has been studied in multiple contexts, such strategic decision making (Perry 1991), technology adaptation (e.g., Orlikowski and Hofman 1997), crises (Hutchins 1991, Weick 1993), and NPD (e.g., Eisenhardt and Tabrizi 1995, Moorman and Miner 1998b).

Although improvisation is sometimes viewed as a failure of formal planning (Moorman and Miner 1998a), the positive role of improvisation has also been cited (e.g., Hatch 1998; Hutchins 1991; Weick 1993, 1995, 1998; Lewin 1998; Majchrzak et al. 2006). Improvisation is thus not inherently good or bad (Vera and Crossan 2005). This is because lack of planning does not necessarily imply inferior results. Improvisation may even be intentionally chosen as a deliberate strategy to avoid a lengthy and costly planning process, particularly when the new conditions are expected to be novel and unique. As Winter (2003) explains, improvisation often occurs strategically as an autonomous decision to take advantage of spontaneity. For example, improvisational artists and comedians intentionally forego prior planning to capture the essence of the moment and spontaneously draw on real-time input from the audience to enhance their performance. Improvisation may also be deliberately employed because the anticipated outcome of spontaneous actions is expected to be superior.

The literature has mostly used jazz or theater as a metaphor for improvisation (e.g., Hatch 1998; Weick 1993, 1998); the goal of musicians is to intentionally come up with new music, whereas organizations need to cautiously change to match new environments while maintaining their stability and structure (Zack 2000). Weick (2001) notes: "Even if organizations are capable of improvising, it is not clear they

[8] The word "improvisation" is formed by the verb "proviso" (that means planning) and the prefix "im" (that suggests lack of). Thus, improvisation suggests lack of planning, and we focus on spontaneous reconfiguration without formal planning.

need to do it" (p. 301). Thus, improvisation is not universally valuable for all organizations, and it should be used judiciously under specific conditions. Following the "science of competitiveness" (Chi et al. 2008a), we presume improvisation to occur and have positive effects in highly turbulent environments with urgent, unanticipated, and impactful storms caused by unpredictable actions of aggressive competitors, unanticipated changes in customer needs, and disruptive technologies that make it impossible to reconfigure through formal planning.

3.1.2. Improvisational Capabilities. To qualify as a capability, the set of actions must be *collective*, *repeatable or patterned*, and *purposeful* (Winter 2003)—not individual, ad hoc, or random.

First, although improvisation has its origins in individuals, it also extends to groups, units, and organizations (Eisenhardt and Tabrizi 1995, Hutchins 1991, Kamoche et al. 2003, Weick 1993). In fact, improvisation has been described as a collective activity (Miner et al. 2001) and a means for collective action (Crossan 1998). Moorman and Miner (1998a) propose the term "collective improvisation" to describe a system of individuals who communally engage in improvisation. Thus, improvisation is viewed as a *collective* capability.

Second, improvisation may be an ad hoc activity because it deals with a new situation each time (Winter 2003). However, evidence suggests that improvisation is a repetitive, patterned, and deliberate activity that can be enhanced with repetition and practice (e.g., Moorman and Miner 1998a, 2001; Weick 1998). This is consistent with Cheng and Van de Ven (1996), who argue that innovation is not a random process, but a patterned one, even if it seems chaotic at first. Crossan et al. (1996, p. 25) argue: "Improvisation is a disciplined craft. Its skills can be learned through continual practice and study." Evidence suggests that organizations often repeat and even institutionalize their improvisational activities (Pressing 1984), learn by observing their best practices and outcomes (Vera and Crossan 2005), and prepare to rely on them when the opportunity for improvisation arises (Weick 1979). Some organizations have developed formal procedures for improvisation, such as The Groop (www.thegroop.com), which describes a formal improvisational process called "the scrum." Thus, organizations that engage in repeated improvisation become aware of their improvisational actions, observe their patterns, and improve their abilities (Moorman and Miner 1998a, 2001). As Weick (1998) explains, improvisation is a patterned, conscious, and deliberate activity that is repeated in response to novel situations and can be enhanced with practice. A close study of fires reveals a pattern in firefighting that can be learned to enhance the ability to put out fires. Although each new situation (or "fire") is likely to be unique and novel, improvisational capability is *not* a random "ad hoc problem solving" (Winter 2003), and preparation, pre-established rules, and rehearsed routines exist (Weick 1998). Organizations realize that they must often be spontaneous and act quickly in urgent situations, and they try to become skilled at improvising through repeated improvisation. The preparation is not specific to each new situation (which is likely to be unique), but preparation occurs in terms of learning how to improvise in *any* unexpected, novel, and unique situation that is likely to emerge. As Moorman and Miner (2001) explain in the context of NPD, single (valuable) instances of improvisational actions are followed by repeated improvisation that starts developing into a capability. Hence, improvisation is a *repeatable* capability that is enhanced with practice.[9]

Third, improvisation is viewed as a capability for frequent and endemic change (Brown and Eisenhardt 1997). Galbraith (1990) views improvisation as a capability to strategically change daily operations to address new environmental situations. Ciborra (1996) also views improvisation as the ability to generate new combinations of resources to address turbulent environments. Orlikowski (1996) describes organizational change as continuous improvisation. Cunha et al. (1999, p. 302) describe improvisation as the "conception of action as it unfolds, drawing on available material, cognitive, affective, and social resources." The classic example of the 1949 Mann Gulch fire disaster (Maclean 1992) describes the idea of improvisation and its valuable role in reconfiguration. In the rapid change of fire conditions that led to the

[9] Although (repeated) capabilities are often plainly viewed as routines, we qualify capabilities as *effective* routines (Winter 2003).

collapse of formal planning (Weick 1993),[10] the firefighter who dropped his tools and improvised by lighting an escape fire survived, whereas the firefighters who upheld existing practices alas perished. The Mann Gulch disaster suggests that improvisation helped develop new operational capabilities by spontaneously relying on existing resources in novel ways. Interestingly, the practice of lighting an escape fire has since become a regular operational capability that all firefighters use (Maclean 1992). This example shows that improvisation in turbulence takes advantage of existing resources in new ways to build new operational capabilities (Weick 1993, pp. 639–640).

This example is consistent with Miner et al. (2001), who describe improvisation as a set of micropatterns that are spontaneously recombined in creative ways.

Therefore,the literature views improvisation as a major means for accomplishing reconfiguration and change, and the goal of improvisational capabilities is to develop new operational capabilities that better respond to novel conditions (e.g., Crossan et al. 2005; Cunha et al. 1999; Weick 1996, 2001). Improvisational capability is thus a *purposeful* capability that aims to reconfigure existing operational capabilities by acting outside past practices to address novel events (Cunha et al. 1999, Weick 1998). This discussion does not imply that improvisation is purposefully utilized to result in new innovations; rather, it is spontaneously used as a means to address novel situations.

3.1.3. Improvisational Capabilities, Improvisational Actions, and the Competitive Dynamics Literature. Improvisational capabilities are consistent in spirit with the competitive dynamics (e.g., Smith et al. 2001) and hypercompetition (e.g., D'Aveni 1994) literatures. These literatures theorize and show that organizations can achieve higher performance by being capable of implementing competitive actions (Grimm and Smith 1997). Competitive actions are viewed as newly developed and externally directed market-based moves that seek to enhance competitiveness by challenging the market status quo through innovations in products and services (Ferrier et al. 1999). Notably, firms that possess a more complex base of capabilities are in a better position to launch competitive actions, also showing that organizations that act more frequently, faster, and with more complexity have a higher performance (Ferrier et al. 1999). This pattern is consistent with Moorman and Miner (2001), who show that repeated successful improvisational actions form the basis of improvisational capabilities, which in turn result in more instances of improvisation in NPD. Thus, competitive actions mediate the link between capabilities and performance (D'Aveni 1994).

In NPD, improvisational capabilities denote the capability to repetitively engage in competitive (improvisational) actions (spontaneous actions without formal planning) by building new products that seek to enhance competitive advantage in NPD, as formally hypothesized below. This distinction draws from Schumpeter (1934), who views competitive actions as the novel combinations of existing resources that arise from the (improvisational) capability to effectively engage in competitive actions.

The awareness-motivation-capability (AMC) framework (Chen 1996) in the competitive dynamics literature explains how firms engage in competitive actions and interfirm rivalry. The AMC framework sees *awareness* to proactively seek opportunities in the environment, *motivation* to undertake competitive actions, and the *capability* to challenge the competitors' actions as the three pillars for undertaking effective competitive actions (see Chi et al. 2007 for a review). These three pillars were shown to raise competitive tension in an industry (Chen et al. 2007) and increase rivalry among multinational organizations (Yu and Cannella 2007). Improvisational capabilities are consistent with the AMC framework in the sense that they reflect the awareness of unpredictable events in the environment and the motivation and ability to respond to them with spontaneous competitive actions. In storms where improvisational capabilities are likely to emerge, there is less emphasis on awareness and motivation and more emphasis on the ability to respond effectively. Hence, improvisational capabilities reflect a specific capability to be aware of, motivated by, and capable of engaging in effective

[10] In his analysis of the Mann Gulch disaster, Weick (1993) introduces the term "bricolage." Improvisation and bricolage are closely related concepts that describe how to spontaneously improvise with limited existing resources (Weick 2001). Also, Vera and Crossan (2005) distinguish improvisation and innovation by viewing improvisation as *spontaneous* innovation.

improvisational actions to address hypercompetitive environments that are characterized by unpredictable moves by aggressive competitors, rapidly changing market needs, and disruptive technologies.

It is important to clarify that improvisational actions are not necessarily always valuable and successful, and it is possible for them to be poor competitive actions that would result in poor outcomes. However, as Moorman and Miner (2001) explain, organizations engage in repeated improvisational actions because such actions have been valuable in the past, thus reflecting a repeated capability to engage in effective improvisational actions with valuable outcomes. Moorman and Miner's explanation underscores the role of improvisational capability in a series of effective competitive (improvisational) actions.

3.1.4. Improvisational Capabilities in NPD. In NPD, the literature has shown that NPD work units learn how to engage in improvisational actions (Eisenhardt and Tabrizi 1995). Improvisational actions, such as the spontaneous introduction of a new product that disrupts market dynamics, have even been viewed as core NPD skills (Brown and Eisenhardt 1995, 1997). Moorman and Miner (2001) give field evidence of organizations that have successfully engaged in repeated improvisational actions that have resulted in an improvisational capability to develop successful new products. Evidence shows that NPD work units repeatedly engage in improvisational actions by brainstorming in real time to rapidly introduce new products to satisfy emerging customer preferences, respond to a new technology, and react to a competitor's new products. The product war between Apple and Research-In-Motion (RIM) in the domain of touch-screen smart phones highlights improvisational actions in NPD. In response to the iPhone's success, RIM introduced the Blackberry Storm with the "SurePress" touch screen, while rushing to introduce the Storm before the 2008 holiday season. Apple has introduced a cheaper iPhone by reconfiguring the iPod Nano with fewer functionalities to respond to the tight economic environment. Thus, improvisational capabilities do exist in NPD, and they are valuable. Miner et al. (2001) report on NPD work units that viewed improvisational capabilities as core strengths. For examples of improvisation in NPD, see Moorman and Miner (1998b) and Miner et al. (2001), and for specific methods to support improvisation, see Majchrzak et al. (2006).

3.2. Improvisational Capabilities vs. Dynamic Capabilities

Because both improvisational and dynamic capabilities aim to reconfigure existing operational capabilities, it is necessary to outline their distinction (Table 1). First, in terms of how they deal with environmental changes, dynamic capabilities aim to predict, sense, and "ride" quasipredictable patterns (waves) in the environment; improvisational capabilities aim to spontaneously respond to unanticipated and unpredictable events (storms). Thus, different types of environmental turbulence create a need for improvisational or dynamic capabilities. Second, in terms of prior planning, whereas dynamic capabilities rely on formal planning for a given situation, planning for improvisational capabilities is not situation specific, but it is "planned spontaneity" by learning how to respond to *any* novel situation. Third, in terms of their underlying nature, improvisational capabilities have an unstructured, emergent, and urgent nature that act in a narrow "window of opportunity"; dynamic capabilities have a structured, stable, and disciplined nature that act in a larger window between planning and execution.[11] Fourth, dynamic capabilities are based on a logic of "planned opportunity" by stressing disciplined flexibility (Eisenhardt and Martin 2000); in contrast, improvisational capabilities are founded on a "logic of spontaneous responsiveness" by reacting to novel situations with spontaneity and intuition.

Pascale's (1984) classic case study of Honda's entry into the U.S. motorcycle market describes the contrast between dynamic and improvisational capabilities along these four dimensions. First, while Honda was planning to seize a market *opportunity* by adapting to

[11] The disciplined nature of dynamic capabilities is evident in the integrative capability (or collective mind)—the ability to heedfully interrelate actions to achieve operational reliability through subordination (Weick and Roberts 1993). The collective mind, which deals with disciplined, mindful, and heedful interrelating to manage existing operations, thus differs from improvisational capabilities, which emphasize spontaneous action to address urgent and novel situations. Whereas the collective mind reflects collective sense-making, improvisation often occurs when sense-making collapses.

Table 1 Major Differences Between Improvisational Capabilities and Dynamic Capabilities

	Improvisational capabilities	Dynamic capabilities
Dealing with the environment ("storms" versus "waves")	Unanticipated environmental events, storms, surprising events, failures, and crises	Predicted and anticipated waves and opportunities in the environment
Nature of prior planning	Planned spontaneity	Disciplined flexibility
Nature of activities	Highly unstructured, urgent, emergent, intuitive, and impromptu activities	Judicious, systematic, stable, and disciplined activities
Logic of competitive action	Logic of "spontaneous responsiveness"	Logic of "planned opportunity"
Time gap between planning and execution	Small gap between planning and execution, narrow "window of opportunity," and inadequate time for formal planning	Sufficient time gap between planning and execution that allows adequate time for formal planning and execution
Limits of action	Acting outside of existing formal plans	Preplanned range of contingencies
Nature of reconfiguration of operational capabilities	Spontaneous and intuitive reconfiguration of new operational capabilities using available existing resources to respond to an urgent, unanticipated, and novel situation	Planned and deliberate reconfiguration of new operational capabilities using predetermined existing resources that related to an anticipated opportunity
Major vulnerabilities	Extreme caution, unwillingness to take risk, extreme confidence in acting without plans	Unwillingness to deal with rigidities, extreme confidence in formal planning
Common misconceptions	Chaotic activities that are completely different from other organizational capabilities, not repeatable, and cannot be enhanced with practice	All capabilities that reconfigure operational capabilities fall into the realm of dynamic capabilities
Déjà vu versus novelty	Novel situations cannot be readily dealt with using existing resources and require creative leveraging for the novel situation	Novel opportunities can be largely addressed with existing resources that are programmed for specific situation
Reliance on individuals	Individual initiatives have a substantial impact on improvisational capabilities	Individual initiatives have a lesser impact on dynamic capabilities
Desirable people qualities	Resilience and recovery skills, creativity, spontaneity, and intuition	Disciplined flexibility, ability to learn and act quickly and judiciously
Analogies	Jazz, improvisational theater, rugby	Race car driving, football

the demands of the U.S. market with large motorcycles through established retailers, the failure of the original plan to attract customer demand spawned a spontaneous action to sell smaller motorcycles through small sports retailers. Second, the planning of dynamic capabilities dealt with a predetermined situation, whereas the emergent plan was based on the spontaneous action of Honda's managers to respond to the novel environmental situations that they did not encounter before. Third, the original plan anticipated a customer need for large motorcycles, and the improvisational action was based on an unanticipated market opportunity to expand into a new market for smaller motorcycles. Finally, although the original plan was well articulated and systematically pursued based on Honda's dynamic capabilities to reconfigure existing operational capabilities in a new market, ensuing actions based on improvisational capabilities were unstructured, urgent, and emergent following a serendipitous meeting between Honda's and Sears' managers.

The proposed distinction between improvisational capabilities and dynamic capabilities is consistent with the work of Eisenhardt and Martin (2000), who also distinguish between two types of capabilities based on the environment in which they operate. In moderately turbulent environments, dynamic capabilities are similar to traditional routines, which are analytic and stable, with predictable outcomes. In contrast, improvisational capabilities in high-velocity markets are viewed as iterative, highly experiential, and contingent processes with unpredictable outcomes. The authors view both processes under the umbrella of dynamic capabilities, but we refer to the former as dynamic capabilities and the latter as improvisational capabilities. In fact, Eisenhardt and Martin (2000) acknowledge that dynamic capabilities are difficult to sustain in high-velocity markets, labeling them instead as "improvisational processes" (p. 1113). This is because dynamic and improvisational capabilities not only differ on the degree of environmental turbulence in which they operate, but they also differ in kind.

As Table 1 shows, these differences include how they *deal with the environment* (planned/anticipated versus spontaneous/unanticipated), *prior planning* (situation-specific versus planned spontaneity), *nature* (structured versus unstructured), and *underlying logic of action* (opportunity versus responsiveness). Thus, see Hypothesis 1.

Hypothesis 1 (H1). *Improvisational capabilities are distinct from dynamic capabilities*.

The proposed distinction between improvisational and dynamic capabilities is also consistent with Collis (1994, p. 145), who proposed three categories of capabilities: the first type refers to operational capabilities, "those that reflect an ability to perform the basic operational activities of the firm." The second category refers to dynamic capabilities, "the ability learn, adapt, change, and renew over time." The third category refers to improvisational capabilities, such as the ability to "recognize the intrinsic value of other resources or to develop novel strategies before competitors." Collis thus also distinguishes between improvisational and dynamic capabilities.

Despite the differences between improvisational and dynamic capabilities, both capabilities emerge from innovation-based competition, in which competitive advantage is based on the *creative destruction* of existing operational capabilities and their *reconfiguration* into superior new operational capabilities (Schumpeter 1934). Also, being "first-order" capabilities that "reconfigure operational capabilities" makes them distinct from ordinary "zero-order" ordinary capabilities that help "make a living" (Winter 2003). This is also consistent with Collis (1994, p. 148), who argues that both improvisational capabilities and dynamic capabilities supersede operational capabilities. Figure 2 depicts the proposed distinction between the three capabilities.

The similarities between the two first-order (improvisational and dynamic) capabilities and their differences from zero-order (operational) capabilities are described in Table 2. Both improvisational and dynamic capabilities aim at reconfiguring new operational capabilities, whereas operational capabilities aim at achieving efficiency and effectiveness through exploitation of existing plans, resources, and skills. This follows Schumpeter's (1934) theory of creative destruction and the competitive dynamics literature, in which existing operational capabilities are destroyed in favor of new ones that better match the environment. Using our environmental analogy, if dynamic capabilities are suitable for "waves" and improvisational capabilities for "storms," operational capabilities would be suitable for "tides" that exploit calm and largely predictable environments with repetition and stability. Applied to NPD, improvisational and dynamic capabilities both denote the ability to reconfigure existing rigid operational capabilities in NPD that were used to build outdated products that no longer match market needs into new operational capabilities for developing competitive, new products that better match the new customer needs.

3.3. Improvisational Capabilities and Competitive Advantage in NPD

Because improvisational capabilities are highly intangible, they are difficult to describe, imitate, and substitute, thus making them a potential source of competitive advantage. In NPD, improvisation occurs by reconfiguring operational capabilities by spontaneously drawing on existing resources to build superior new ones to match changing market needs, technologies, and competitors' new products. Given the unstructured nature of improvisational capabilities that deal with a novel situation each time, it is difficult to specify universal means by which improvisational capabilities reconfigure new operational capabilities. However, there are many instances of competitive actions that draw on improvisational

Figure 2 **Dynamic Capabilities, Improvisational Capabilities, and Operational Capabilities**

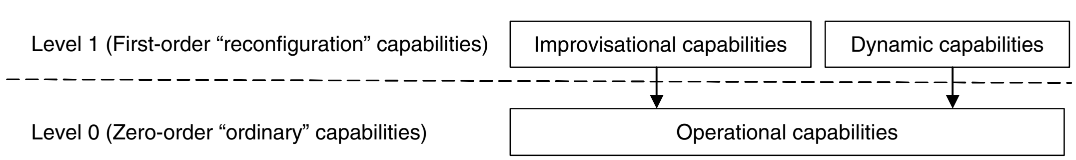


Table 2 Differences Between First-Order (Reconfiguration) and Zero-Order (Operational) Capabilities

	Improvisational capabilities and dynamic capabilities	Operational capabilities
Desired outcome	Superior new operational capabilities that better match emerging market needs and environmental conditions	Improving efficiency (cost, time) and effectiveness (quality)
Principle of action	Reconfiguration of new operational capabilities by leveraging existing organizational resources in new ways	Lean operations through repetition and stability
Foundation of action	General knowledge and cross-functional capabilities about market needs, competitors' actions, and new technologies	Function-specific skills, knowledge, and resources
Mode of action	Exploration of environmental events and new opportunities	Exploitation of opportunities
Desirable people qualities	Willingness to change, dealing with uncertainty, recognizing the value of existing resources, awareness, innovativeness, responsiveness, curiosity, complex sensing, and adaptability	Adherence to formal plans, focus on efficiency and stability, attention to detail
Limits of action	Acting outside existing plans to promote change	Adhering to existing plans
Vulnerabilities	Unwillingness to take risks or change, extreme reliance on existing plans and standard operating procedures	Environmental turbulence, rigidities, constant change
Environmental analogies	Waves and storms in turbulent environments	Tides in calm environments

capabilities to develop successful new products (Brown and Eisenhardt 1997, Eisenhardt and Tabrizi 1995, Moorman and Miner 1998b, Miner et al. 2001).

Evidence from improvisational comedy suggests that the final product may become more successful when actors are asked to improvise in weakly structured situations rather than strictly following a script. For example, HBO's hit comedy *Curb Your Enthusiasm* with Seinfeld's cocreator Larry David encourages improvisation by not having a script but only a few weak guidelines. The actors have collectively developed their improvisational capabilities over time, and they are not just "flying blind." Their success is based on planned spontaneity and the practiced ability to take advantage of spontaneity to creatively address consciously induced novel situations.

The competitive dynamics literature has shown that effective competitive actions enhance firm performance (e.g., D'Aveni 1994, Ferrier et al. 1999), explaining that a set of competitive actions over time builds a long-term competitive advantage via many temporary advantages (Chi et al. 2008a). D'Aveni illustrates how the moves and countermoves by Pepsi and Coca-Cola leapfrogged each other with temporary advantages. Therefore, improvisational capabilities can enhance the quality of competitive actions to support competitive strategy. Evidence shows that organizations that quickly respond to competitive new product introductions with new products enjoy higher stock returns (Lee et al. 2000). Pisano (1994) also shows that learning by doing with frequent experimentation and real-time prototyping (resembling improvisational capabilities) are valuable capabilities in the biotech industry. Moreover, the capability to spontaneously respond to crises (Hutchins 1991, Weick 1993), aggressively react to competitors (Miner et al. 2001), match changing market needs and emerging technologies (Brown and Eisenhardt 1997), and support improvisational decisionmaking in real time (Perry 1991) help build a series of temporary advantages in NPD with the competitive introduction of new products. Thus, we propose:

Hypothesis 2 (H2). *Improvisational capabilities are positively associated with superior operational capabilities in NPD.*

H2 is consistent with D'Aveni (1994), who views competitive advantage in hypercompetitive environments as short lived because organizations frequently launch competitive actions to disrupt their rivals' positions, thus forcing organizations to continually undertake competitive actions to gain and regain a competitive advantage. Improvisational capabilities are thus important means for spontaneously engaging in such competitive actions.

3.4. Effects of Improvisational Capabilities in Turbulent Environments

Environmental turbulence creates unexpected conditions that call for novel solutions (Vera and Crossan 2005). For example, the unexpected introduction of a new product by a competitor makes existing plans less relevant and raises the need for improvisation to come up with new products. The unexpected huge success of the iPhone raised the urgency for RIM to rapidly develop a competing new product. Environmental turbulence makes it likely that existing operational capabilities no longer meet customer needs, forcing NPD work units to exercise their improvisation capabilities to adapt to novel events with new products (Moorman and Miner 1998b). Disruptive new technologies and technological breakthroughs by competitors also force NPD work units to improvise to urgently employ new technologies in existing products, such as touch-screen technology into the RIM Blackberry Storm. Finally, rapid changes in customer demands, such as the need for intuitive touchpad screens for mobile devices, also call for NPD work units to improvise to rapidly meet these new customer demands with new products.

Because the need for reconfiguring operational capabilities is more likely in more turbulent environments (Kogut and Zander 1992), the impact of improvisational capabilities on operational capabilities (H2) is proposed to be moderated by turbulence. As the successful execution of a capability depends on its frequent practice (Winter 2003), turbulent environments favor improvisational capabilities. The spontaneous nature of improvisation is ideally suited for highly turbulent environments. Improvisation may even be the only feasible choice in turbulent environments because planning may not be appropriate (given possible unpredictable events) or even feasible (given not enough time to engage in planning) (Crossan et al. 2005). Vera and Crossan (2004) suggest that the relationship between improvisation and performance is equivocal, with improvisation being more valuable under unpredictable conditions and time pressure. Pisano (1994) shows that experimentation and prototyping are most valuable in the highly turbulent biotech industry. In contrast, Moorman and Miner (1998b) argue that improvisation in low degrees of environmental turbulence could be disruptive. Therefore, we propose the following hypothesis.

Hypothesis 3 (H3). *The positive relationship between improvisational capabilities and operational capabilities in NPD is positively moderated (reinforced) by environmental turbulence.*

3.5. Improvisational vs. Dynamic Capabilities in Turbulence

Both dynamic capabilities and improvisational capabilities are likely to be more valuable as the environment becomes more turbulent. However, because these two capabilities are distinct (H1) and even competing means for reconfiguration, we theorize and empirically test which capabilities would be the most effective in reconfiguring operational capabilities in different degrees of environmental turbulence.

On the one hand, organizations that invest in dynamic capabilities are generally better prepared to change. *Ceteris paribus*, the field of strategic management generally favors judicious strategic planning (Weick 1994). As Cohen and Levinthal (1994, p. 227) argue, “Fortune favors the prepared firm.” Thus, when it is possible to anticipate predictable patterns of change (waves) in moderately turbulent environments, dynamic capabilities may be the optimum option by drawing on past experience to plan reconfiguration.

On the other hand, organizations may not always have the luxury of planning, and improvisational capabilities may be the only viable means for change in unexpected storms, where action must be taken urgently without prior planning. Improvisational capabilities are likely to be effective when the environment is so turbulent with frequent storms that sense-making collapses (Weick 1993) and past experience offers little help. Improvisational capabilities also help speed action by avoiding the lengthy reconfiguration process often required by dynamic capabilities (Eisenhardt and Tabrizi 1995). Brown and Eisenhardt (1997) see improvisation as ideally suited for highly turbulent environments. Also, organizations that rely on improvisational capabilities may reconfigure faster and more cheaply than dynamic capabilities that require costly formal planning (Winter 2003). Hence, although dynamic capabilities are expected to be more effective in moderately turbulent environments, improvisational capabilities may trump dynamic capabilities in highly turbulent environments. Thus, we propose the following hypothesis.

Hypothesis 4 (H4). *Improvisational capabilities have a stronger effect on operational capabilities in NPD than* *dynamic capabilities in more turbulent* (*highly turbulent*) *environments*, *but dynamic capabilities have a stronger effect than improvisational capabilities in less* (*moderately*) *turbulent environments*.

3.6. IT-Leveraging Capability and Improvisational Capabilities

Because competitive actions and organizational capabilities are often inseparable from IT (Ferrier et al. 2007), improvisational capabilities can be enhanced with appropriate IT. Following the AMC framework (Chen et al. 2007), the effective use of IT systems is proposed to enhance the ability to undertake competitive actions by enhancing the awareness, motivation, and capability to execute competitive (improvisational) actions (Chi et al. 2008b).

Pavlou and El Sawy (2006) examined the aggregate role of IT-leveraging capability in NPD, to examine the role of individual IT systems on improvisational capabilities, but we break down IT-leveraging capability into its three underlying system components, namely the effective use of PRMS, OMS, and CWS. This follows the call by Mukhopadhyay et al. (1995) to focus on *specific* IT systems to examine their unique and often idiosyncratic effect.

The proposed effect of IT systems is based on Vera and Crossan (2005), who proposed three conditions that must be in place for effective improvisation: first, a set of *rules* must be in place to enable the management of existing resources (Vera and Crossan 2005). Second, *memory* from past projects helps create awareness of past improvisational actions and procedures that may be used for the focal situation (Mendonça 2007). Third, *real-time information and communication*, the concurrent interaction among people based on immediate feedback, can facilitate brainstorming, creativity, and problem solving (Brown and Eisenhardt 1995). These three conditions are proposed to be enhanced by the effective use of PRMS, OMS, and CWS, respectively.[12]

3.6.1. Effective Use of PRMS. Improvisation is based on identifying and drawing on existing resources to spontaneously create new resource combinations (Miner et al. 2001). Because improvisation is a patterned capability that can be enhanced with practice, a set of rules for managing existing resources provides the foundations for effective improvisation (Vera and Crossan 2005). The effective use of PRMS is proposed to enhance the improvisational capabilities of NPD work units with its two key functionalities. First, the *project* functionalities of PRMS enable task scheduling, task assignment, and time management, thus helping bring forth rules and structures to guide improvisation. By visualizing project status in real time, offering visibility of real-time project status, and rapidly tracking tasks, PRMS help NPD work units become aware of their improvisational actions as they unfold, observe successful patterns, and enhance their improvisational capabilities. Second, the *resource* functionalities of PRMS enhance management of resources by modeling the availability, usage, and cost of people, skills, and other resources. By offering real-time information on existing resources, the effective use of PRMS builds awareness of resource synergies, thus making it easier to spontaneously allocate and recombine resources in new configurations.

Hypothesis 5A (H5A). *The effective use of PRMS is positively associated with improvisational capabilities*.

3.6.2. Effective Use of OMS. The proposed effect of OMS on improvisational capabilities is justified on three key functionalities of OMS: First, the *knowledge coding* functionality of OMS helps code, archive, and store knowledge and best practices from past projects, thus enabling NPD work units to store and reuse successful actions in novel conditions. Organizations can benefit by coding and institutionalizing their past improvisational actions (Pressing 1984). Second, the *knowledge directories* functionality of OMS helps NPD work units become aware of best practices and knowledge from past projects that may be useful for novel conditions. Moorman and Miner (1998b) show that NPD work units with high past memories can engage in effective improvisation by "mixing and matching" existing procedures and materials in novel ways (Mendonça 2007). Third, the *knowledge retrieval* functionality of OMS facilitates access to stored knowledge and memory, thus helping NPD

[12] Although there is not a strict one-to-one relationship among these three preconditions and the three proposed IT systems, the functionalities of each IT system have a predominant role in facilitating each of the three conditions, respectively.

work units draw on past effective improvisational actions to come up with new ones (Moorman and Miner 2001). Awareness of past projects allows NPD units to utilize past practices that facilitate improvisation (Vera and Crossan 2005). Thus, we have Hypothesis 5B.

Hypothesis 5B (H5B). *The effective use of OMS is positively associated with improvisational capabilities.*

3.6.3. Effective Use of CWS. Because improvisational capabilities are inherently collective activities, they rely on group communication to address novel conditions under time pressure (Weick 2001), spontaneously solve new problems in real time (Vera and Crosan 2005), and remain creative in new situations (Weick 1993). Because improvisation is based on sharing and building on each other's ideas (Moorman and Miner 1998a), the effective use of CWS is proposed to enhance improvisational capabilities by enabling collaborative work with its three key functionalities. First, the *conveyance* functionality, which helps describe product structures and configurations, enables NPD work units to be forthcoming in sharing their ideas. For example, CAD visualization tools allow NPD work units to collectively view engineering drawings and manage content in real time from any location (Ettlie and Pavlou 2006), facilitating improvisation. Second, the *presentation* functionality allows NPD work units to manipulate the their contributions, integrate various ideas, and take advantage of real-time input. By giving new meaning to past contributions and transforming new ideas, the presentation functionality of CWS helps NPD work units find novel solutions, thus facilitating improvisation. Third, the *convergence* functionality of CWS, such as desktop sharing, helps NPD work units simultaneously act as a team, thus facilitating teamwork, brainstorming, and convergence of ideas; all of these enhance improvisation (Vera and Crossan 2004). Brown and Eisenhardt (1995) show that NPD work units with advanced IT systems have the ability to respond to new situations. By enabling real-time communication, CWS enhance the ability of NPD work units to develop new thinking, pursue new product initiatives, and find innovative solutions (McKnight and Bontis 2002). Real-time information helps NPD work units react quickly to novel events (Eisenhardt 1989), and lack of up-to-date information raises the risk of improvisation failure (Vera and Crossan 2005). In sum, by helping NPD work units convey, present, and shape their perspectives into new combinations of product ideas, the effective use of CWS helps enhance improvisational capabilities.

Hypothesis 5C (H5C). *The effective use of CWS is positively associated with improvisational capabilities.*

3.7. Effect of IT-Leveraging Capability on Improvisational Capabilities in Turbulence

There is a consensus that IT capabilities are more valuable in turbulent environments (Hitt et al. 1998, Orlikowski and Hofman 1997, Pavlou and El Sawy 2006). Because environmental turbulence stresses the need for real-time information (Hitt et al. 1998) and because improvisational capabilities heavily depend on real-time information (Vera and Crossan 2005), the effective use of IT to support real-time information and knowledge flows becomes more pronounced in turbulence (Mendelson 2000).

3.7.1. Effects of PRMS on Improvisational Capabilities in Turbulence. As hypothesized in H5A, the effective use of PRMS enhances improvisational capabilities by setting the rules for improvisation and helping NPD work units identify, value, and draw on existing resources to create new combinations of resources. First, the *project* functionalities of PRMS—which entail the rules of improvisation by visualizing project status, offering visibility on project data, and tracking project assignments in real-time—become more valuable in turbulence that requires NPD work units to be aware of their improvisation actions in real time. Second, the *resource* functionalities of PRMS, which help NPD work units identify synergies among resources, model their availability, usage, and cost; and spontaneously recombine them in new combinations become more valuable in environmental turbulence that requires real-time awareness of resource availability. Thus, we propose that the role of PRMS in improvisational capabilities is higher in more turbulent environments.

Hypothesis 6A (H6A). *The positive relationship between the effective use of PRMS and improvisational capabilities in NPD is positively moderated* (*reinforced*) *by environmental turbulence.*

3.7.2. Effects of OMS on Improvisational Capabilities in Turbulence. As hypothesized earlier (H5B), the effective use of OMS enhances improvisational capabilities by bringing to bear past knowledge and memory. First, the *knowledge coding* functionality, which enables NPD work units to increase their awareness of past best practices by coding, archiving, and storing product-specific knowledge and best practices from past projects, becomes more valuable in turbulent environments that are likely to spawn more opportunities for improvisation that may benefit from past improvisational actions. Second, the *knowledge directories* functionality, which helps NPD work units locate past improvisational actions, becomes more valuable in turbulent environments that are more likely to create instances for such best practices to be reused in novel conditions. Third, the *knowledge retrieval* functionality, which helps NPD work units retrieve stored knowledge, becomes more valuable in turbulence that generates a higher need for improvisation. Because the role of all three OMS functionalities becomes more valuable in turbulence, we propose the following hypothesis.

Hypothesis 6B (H6B). *The positive relationship between the effective use of OMS and improvisational capabilities in NPD is positively moderated* (*reinforced*) *by environmental turbulence.*

3.7.3. Effects of CWS on Improvisational Capabilities in Turbulence. As proposed in H5C, the effective use of CWS enhances improvisational capabilities by enabling collaborative work that is needed for collective brainstorming and problem solving. First, the *conveyance* functionality, which enables NPD work units to share their individual expertise and ideas and collectively work on products in real time by enabling collaboration (Ettlie and Pavlou 2006), becomes more valuable in turbulent environments that require transforming individual ideas to a collective output under time pressure. Second, the *presentation* functionality, which helps NPD work units develop new product ideas by giving new meaning to existing ideas, becomes more valuable in turbulence that requires a larger number of ideas to be integrated. Third, the *convergence* functionality of CWS, which helps NPD work units integrate ideas, develop new thinking, and pursue new product initiatives through real-time communication, brainstorming, and convergence of ideas, becomes more valuable in turbulent environments that require rapid communications to enable NPD work units to remain creative as a group in novel and unexpected situations. Thus, we hypothesize as follows.

Hypothesis 6C (H6C). *The positive relationship between the effective use of CWS and improvisational capabilities in NPD is positively moderated* (*reinforced*) *by environmental turbulence*.

Integrating the proposed set of hypotheses, the resulting research model is shown in Figure 3.

4. Research Methodology

4.1. Measurement Instrument

The measurement scales (Table 3) are based on existing scales from the literature that have been adapted to match the study's NPD context. The exact measurement items are shown in Supplementary Appendix 1.[13]

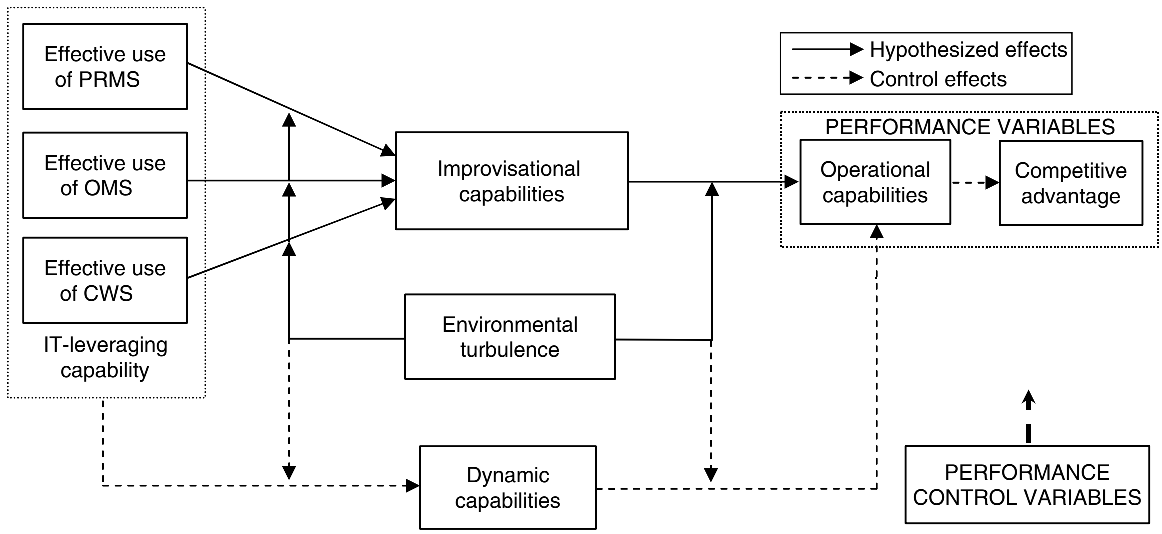
The study's control variables are described in Table 4 (Brown and Eisenhardt 1995, Clark and Fujimoto 1991).

4.2. Data Collection

Two studies with NPD managers were conducted in the United States with the same data collection protocol. First, we identified participants from the 2002 Product Development and Management Association conference; second, we identified the participants of the 2003 Roundtable Management conference. The two samples had 386 and 121 NPD managers, respectively. Invitation e-mails were then sent, explaining the study's purpose and requesting the NPD managers' participation. The e-mail body assured that the responses would be treated confidentially and the results would only be reported in aggregate. The respondents were asked to click on a URL link in the e-mail message that linked to our online instrument. The respondents were offered as incentive a customized report that summarized the study's

[13] Additional information is contained in an online appendix to this paper that is available on the *Information Systems Research* website (http://isr.pubs.informs.org/ecompanion.html).

Figure 3 The Proposed Model and Research Hypotheses



results (more than 90% of the respondents requested this report). For the first study, 121 responses were received (39% response rate). For the second study, 59 responses were obtained (43% response rate) (total 180 responses). The response rates are higher than most survey studies in NPD because personal communication was sought with the study's participants, the study was supported by the conference organizers, one author participated in the conferences and established personal contacts with the respondents, and responses through paper questionnaires were also collected during the two conferences.[14]

In the survey instructions, the respondents were asked to select a NPD work unit they were managing.[15] To avoid social desirability bias, the respondents were asked to select a work unit that they are mostly familiar with, and not a typical, successful, or a failed one.[16] A formal check assessed the respondents' familiarity with their NPD work units. Using a cutoff point of 4 (with 4 anchored at "very familiar" and 5 at"extremely familiar"), all respondents (mean = 4.31, STD = 0.84) were deemed knowledgeable and all responses were retained.

5. Data Analysis and Results

Data analysis was conducted with partial least square (PLS), a structural equation modeling method that uses a component-based approach to estimation. Because of the large number of variables, interaction effects, and second-order variables, PLS was deemed most appropriate (Chin 1998). PLS-Graph Version 3.0 was used.

5.1. Testing the Measurement Model

First, reliability was assessed with the PLS internal consistency measure. All values were above 0.70

[14] Nonresponse bias was assessed by verifying that early and late respondents did not significantly differ in their demographic characteristics and survey responses (Armstrong and Overton 1977). All t-tests between the means of the two groups showed no significant differences ($p < 0.1$ level). These tests suggest lack of nonresponse bias problems.

[15] To collect both intra- and interfirm NPD work units, the respondents were asked to favor selecting external NPD units, which helped collect 56% of the responses on interfirm work units. If the respondents selected an interfirm unit, they were asked to provide the contact information of the respective NPD manager from the partner firm. From the 99 interfirm work units, 47 names were received, and 28 matched pairs were finally obtained (60% response rate). The average absolute differences for all constructs were less than 5%, the average correlation between the two respondents was 0.63 (range = 0.17–0.87), and the interrater reliability was very high ($r = 0.71$). These results indicate no systematic bias between the two informants, and their responses were averaged to derive a single score for each interfirm NPD work unit.

[16] To address social desirability bias, the performance outcomes for all NPD work units were examined. The mean of the performance variables was 3.44 on a five-point scale (roughly in the middle of the scale), implying no social desirability bias.

Table 3 Operationalization of the Study's Principal Constructs

Improvisational capabilities in NPD

Improvisational capabilities were measured based on Moorman and Miner's scale (1998b). The items were adapted to the NPD context to reflect the ability to undertake successful improvisational actions by NPD work units relative to the competition.

IT-leveraging capability in NPD

This construct was measured based on the work of Pavlou and El Sawy (2006), aiming to assess the extent to which IT functionalities are effectively used by NPD work units. First, the effective use of PRMS focused on the use of *scheduling and time management*, *resource management*, and *task assignment* functionalities (Rangaswamy and Lilien 1997). Second, the effective use of OMS was measured based on the work of Alavi and Leidner (2001), focusing on the effective use of IT functionalities for *coding and sharing of knowledge*, *creation of knowledge directories*, and *knowledge networking*. Third, the effective use of CWS was based the study by Wheeler et al. (1999), capturing the effective use of *conveyance*, *presentation*, and *convergence* functionalities. For validation purposes, we also measured the overall degree of IT-leveraging capability in NPD with two direct indicator items (Appendix 1).

Environmental turbulence

Environmental (market and technological) turbulence was measured following Jaworski and Kohli (1993). A new indicator scale of *overall* environmental turbulence was also developed for validation purposes (Appendix 1).

Dynamic capabilities in NPD

The scale of dynamic capabilities is based on the work of Pavlou and El Sawy (2006).[a] First, *sensing capability* (or market orientation) captures the generation, dissemination, and responsiveness to market intelligence (Jaworski and Kohli 1993). Second, *learning capability* (or absorptive capacity) captures the acquisition, assimilation, transformation, and exploitation of knowledge (Cohen and Levinthal 1990). Third, *coordinating capability* captures resource allocation, task assignment, and synchronization (Crowston 1997). Fourth, *integrating capability* captures the contribution, representation, and interrelation of individual inputs (Weick and Roberts 1993). The second-order measure of dynamic capabilities was tested with three *indicator* items, such as: "We can successfully reconfigure our resources to come up with new productive assets."

Operational capabilities in NPD

Customer and technical capabilities were measured following Song and Parry (1997); managerial capability was measured following Sethi et al. (2001). Overall NPD capability was measured as an indicator variable (Vorhies and Harker 2000).

Competitive advantage in NPD

This is operationalized as the *combination* of process efficiency and product effectiveness by multiplying the efficiency and effectiveness items (Kenny and Judd 1984).[b] Because self-reported scales may be biased, archival data from firm records were matched with the managers' self-reported measures for 64 firms for which we could collect firm-level performance data.[c] Even if overall firm performance may not reflect the performance of NPD work units, it is a reasonable validation check.[d]

[a]The original scale includes 34 measurement items for the four dimensions of dynamic capabilities and 3 indicator items (Pavlou and El Sawy 2006). A more parsimonious scale with 12 measurement items was refined in a more recent work (El Sawy and Pavlou 2008). Separate analyses were performed with both scales, which rendered very similar results. The analysis was also performed with only the three indicator items for dynamic capabilities that also rendered very similar results. These findings indicate that the measurement of dynamic capabilities is quite robust irrespective of the number of items.

[b]This view places equal weights on the two dimensions; yet firms often focus on one dimension, such as cost differentiation (Porter 1980). Nonetheless, firms cannot place excessive focus on any one dimension because of the risk of being left behind by competitors that focus on both (Sethi et al. 2001). The correlation between product effectiveness and process efficiency is $r = 0.16$ ($p = 0.049$), that is, not very high, supporting the trade-off (Clark and Fujimoto 1991). A *simple* and *weighted* average was also tested. Although all weights are highly correlated ($r = 0.93$ and 0.89), the interaction term is consistent with our conceptualization.

[c]The regression values weighted by the NPD unit's over the firm's size are $b = 0.18$ (ROA), $b = 0.20$ (ROS), and $b = 0.25$ (SG) ($p < 0.05$).

[d]As archival performance sources are not available for NPD work units, we included two competitive advantage measures for validation. A perceptual measure of competitive advantage was used (Jap 2001) that was highly correlated with the proposed measure ($r = 0.67$, $p < 0.01$). Three accounting ratios—return on sales, return on assets, and sales growth—were captured at the NPD unit level as three-year average values (Atuahene-Gima and Li 2004). Return on sales is the ratio of net operating income over sales (proxy of product quality) and is highly correlated with product effectiveness ($r = 0.68$, $p < 0.01$). Return on assets is the ratio of net operating income over total assets (proxy for process efficiency) and is correlated with process efficiency ($r = 0.74$, $p < 0.01$). Sales growth measures the rate of change of product sales over the past three years (key indicator of market acceptance of new products); it is correlated with product effectiveness ($r = 0.29$, $p < 0.01$), process efficiency ($r = 0.34$, $p < 0.01$), and their interaction ($r = 0.55$, $p < 0.01$).

(Table 5), implying adequate reliability. Second, convergent and discriminant validity is inferred when the PLS indicators load much higher on their own factor than other factors and when the average variance extracted (AVE) is larger than its correlations with other constructs (Chin 1998). As shown in Table 5, all AVEs were above 0.70 (excluding formative indicators shown in italics), and they are much larger than all cross-correlations.

Discriminant and convergent validity was examined with the confirmatory factor analysis procedure in PLS. All items load well on their hypothesized factors (above 0.81), which are higher than all cross-loadings (below 0.51).

Table 4 Control Variables

Cross-functional integration Cross functional integration captures the quality of interaction among the different operational areas, and it was shown to influence NPD performance (Clark and Fujimoto 1991). A three-item scale was used following Song and Parry (1997).
Product innovation type Innovation type is measured as (1) routine engineering of existing products, (2) building new products based on existing ones, and (3) developing radically new products.
Work unit's experience in NPD The work unit's experience (years) is controlled for its role in competitive advantage in NPD (Song and Parry 1997).
Work unit size This variable measures the size (number of members) of the focal NPD work unit.
Firm size This control variable is operationalized as both the number of employees in the organization and the organization's revenues.
Industry segment The industry segment in which the NPD work unit operates is controlled for its effect on competitive advantage in NPD.
Respondent's rank Whether the respondent was a senior (executive) or mid-level NPD manager is also controlled for.

Common method bias was assessed with three tests (Pavlou and Gefen 2004). First, Harman's one-factor test in a principal components factor analysis (Podsakoff and Organ 1986) showed that each variable explains roughly equal variance, indicating lack of common method bias (range = 3.8%–10.4%; total variance explained = 83%). Second, NPD performance was measured with interaction effects that were verified with secondary data (Table 3). Finally, Table 5 reports the correlation matrix, which does not show any exceptionally correlated variables.

5.2. Hypotheses Testing

To test the theoretical distinction between improvisational and dynamic capabilities (H1), we examined whether improvisational and dynamic capabilities (1) factor independently, (2) coexist without acting in the same way, and (3) have different relationships with other variables. First, a PLS confirmatory factor analysis shows improvisational and dynamic capabilities to be discriminant with distinct loadings (omitted for brevity). Second, dynamic and improvisational capabilities have a modest correlation ($r = 0.42$) (Table 5). Third, dynamic capabilities and improvisational capabilities have different relationships with their antecedents (IT systems) (see Table 8), consequences (operational capabilities), and moderating roles (environmental turbulence), as Figure 4 attests. These tests suggest that improvisational and dynamic capabilities are distinct variables, thereby supporting H1.

The second-order models for dynamic capabilities, operational capabilities, and environmental turbulence were simultaneously derived with the PLS structural model (Diamantopoulos and Winklhofer 2001). The levels of significance of the coefficients were obtained with bootstrapping ($n = 500$). The control effects are shown in Table 6.

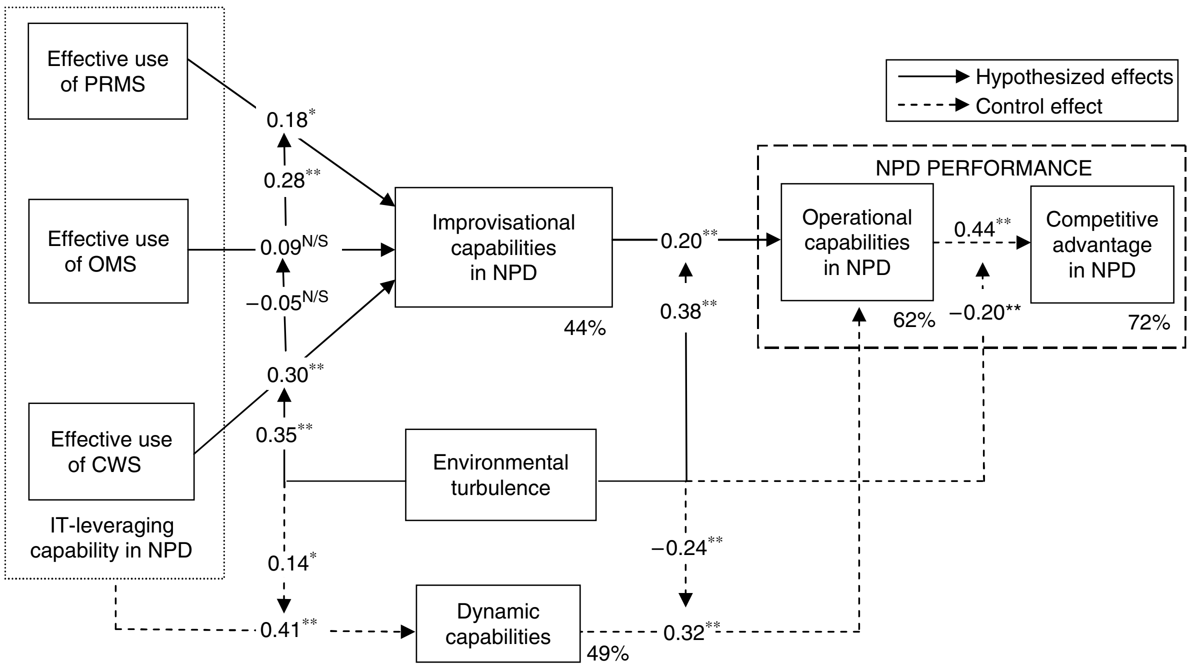
As shown in Figure 4, operational capabilities have a significant impact on competitive advantage in NPD, confirming our assumption that NPD performance is based on operational capabilities (Clark and Fujimoto 1991). Despite the significant (control) effect of both dynamic capabilities and the other control variables (Table 6), improvisational capabilities ($\beta = 0.20$, $p < 0.01$) still have a significant effect on operational capabilities in NPD, thus supporting H2. The moderating role of environmental turbulence on

Table 5 Correlation Matrix and Composite Factor Reliability Scores for Principal Constructs

Construct	Reliability	Mean (STD)	CA	DC	IC	OC	ITC	PRMS	OMS	CWS	ET
Competitive advantage (CA)	**0.91**	**14.65** (**3.75**)	**0.87**								
Dynamic capabilities (DC)	**0.89**	**3.65** (**0.84**)	0.41	**0.86**							
Improvisational capabilities (IC)	**0.88**	**3.61** (**0.79**)	0.24	0.42	**0.83**						
Operational capabilities (OC)	**0.83**	**3.33** (**0.99**)	0.57	0.41	0.34	**0.85**					
IT capability in NPD (ITC)	**0.95**	**2.53** (**1.25**)	0.22	0.51	0.41	0.30	**0.94**				
Effective use of PRMS (PRMS)	**0.89**	**2.60** (**1.14**)	0.26	0.26	0.31	0.32	*0.89*	**0.90**			
Effective use of OMS (OMS)	**0.89**	**2.63** (**1.40**)	0.12	0.40	0.20	0.25	*0.91*	*0.70*	**0.85**		
Effective use of CWS (CWS)	**0.91**	**2.45** (**1.45**)	0.20	0.41	0.45	0.26	*0.89*	*0.66*	*0.74*	**0.79**	
Environmental turbulence (ET)	**0.85**	**3.28** (**1.26**)	0.28	0.22	0.27	0.17	0.18	0.20	0.15	0.14	**0.73**

Notes. Items on diagonal (in bold) represent AVE scores. Correlations above 0.15 are significant ($p < 0.05$); above 0.20 ($p < 0.01$).

Figure 4 PLS Results for the Proposed Research Model



Note. Variance explained (R^2) in percentage.
*Significant at $p < 0.05$; **significant at $p < 0.01$; N/S nonsignificant.

improvisational capabilities is also significant ($\beta = 0.38$, $p < 0.01$), supporting H3. In contrast, the nonhypothesized moderating role of environmental turbulence on the effect of dynamic capabilities ($\beta = -0.24$, $p < 0.01$) is negative, implying that dynamic capabilities have a weaker effect as the environment becomes more turbulent, whereas improvisational capabilities have a stronger effect ($p < 0.001$). Jointly these findings support H4. In terms of the effects of the three digital IT systems, PRMS have a significant effect ($\beta = 0.18$, $p < 0.05$) on improvisational capabilities; this effect is significantly positively moderated by environmental turbulence ($\beta = 0.28$, $p < 0.01$), thus supporting H5A and H6A. OMS have an insignificant weak effect on improvisational capabilities; besides, the moderating role of environmental turbulence is insignificant. These findings fail to support H5B and H6B. Finally, CWS have a significant effect on improvisational capabilities ($\beta = 0.30$, $p < 0.01$), an effect that is significantly moderated by environmental turbulence ($\beta = 0.35$, $p < 0.01$). These findings support H5C and H6C.

Table 6 Control Effects on Dependent Variables

Control variables/ dependent variables	Improvisational capabilities	Dynamic capabilities	Operational capabilities	Competitive advantage
Cross-functional integration	0.14*	0.11N/S	0.16*	0.18*
Product innovation type	0.25**	0.21**	0.22**	0.05N/S
Work unit experience	0.13*	0.19*	0.15*	0.11N/S
Work unit size	−0.11*	0.07N/S	0.08N/S	0.14*
Firm size	−0.06N/S	−0.03N/S	0.10N/S	0.17*
Environmental turbulence	0.31**	0.19*	−0.25**	0.02N/S

*Significant at $p < 0.05$; **significant at $p < 0.01$; N/S nonsignificant.

In addition to the high R^2 values in Figure 4, the Q^2 values were calculated for the dependent variables (Table 7). As all Q^2 values are higher than zero, the model has predictive validity on all dependent variables (Chin 1998).

To shed light on the effects of the IT systems, we compare the individual effect of each IT system on both improvisational and dynamic capabilities. As shown in Table 8, all three digital IT systems have a positive effect on dynamic capabilities. However, only the effect of OMS on dynamic capabilities is moderated by turbulence. In contrast, OMS do not

Table 7 The Q^2 Statistic Values for the Proposed Research Model

Q^2 statistic	Improvisational capabilities	Dynamic capabilities	Operational capabilities	Competitive advantage
Cross-validated communality Q^2	0.55	0.48	0.73	0.80
Cross-validated redundancy Q^2	0.43	0.37	0.55	0.63

Table 8 The Relative Effect of the Proposed IT Systems on Improvisational and Dynamic Capabilities

	Dynamic capabilities		Improvisational capabilities	
	Direct effect	Interaction effect	Direct effect	Interaction effect
Effective use of PRMS	0.22**	0.08N/S	0.18*	0.28**
Effective use of OMS	0.31**	0.17*	0.09N/S	0.05N/S
Effective use of CWS	0.27**	0.04N/S	0.30**	0.35**

*Significant at $p < 0.05$; **significant at $p < 0.01$; N/S nonsignificant.

have either a significant direct or an interaction effect on improvisational capabilities.

The interaction effects were tested with Cohen's f^2 by comparing the main and interaction effects with Equation (1) following Pavlou and Gefen (2005):

$$\text{Cohen's } f^2 = R^2 \text{ (interaction model)} - R^2 \text{ (main effects model)} / [1 - R^2 \text{ (main effects model)}]. \quad (1)$$

As shown in Table 9, the moderating role of turbulence on the role of improvisational capabilities is significant ($\Delta R^2 = 12.4\%$) and Cohen's $f^2 = 0.25$. However, the corresponding moderating role of environmental turbulence on the effect of dynamic capabilities only explains $\Delta R^2 = 6.5\%$ that denotes a small-medium Cohen's f^2 effect. This implies that the effects of improvisational capabilities are much more severely moderated by environmental turbulence. These Cohen's f^2 results were verified with the F-statistic (Carte and Russell 2003, Pavlou and Dimoka 2006).

5.3. Dynamic Capabilities and Improvisational Capabilities in Turbulent Environments

To examine the relative role of improvisation and dynamic capabilities in different levels of turbulence (H4), clusters were formed based on market

Table 9 Cohen's f^2 Tests for the Proposed Interaction Effects of Environmental Turbulence

Hypothesis	Moderating effect of environmental turbulence	ΔR^2 (%)	Cohen's f^2	Effect size
H1	**Improvisational capabilities → Operational capabilities**	**12.4**	**0.25**	**Large**
Control	Dynamic capabilities → Operational capabilities	6.5	0.11	Small–medium
H5A	**Effective use of PRMS → Improvisational capabilities**	**8.3**	**0.31**	**Large**
H5B	**Effective use of OMS → Improvisational capabilities**	**0.3**	**0.01**	**None**
H5C	**Effective use of CWS → Improvisational capabilities**	**9.1**	**0.34**	**Large**
Control	IT-leveraging capability → Dynamic capabilities	5.1	0.09	Small–medium

Table 10 Cluster Analysis Results and Cluster Validation

Variable	Cluster 1 ($n = 53$)	Cluster 2 ($n = 127$)	t-value	Comparison
Market turbulence	4.5 (0.65)	3.2 (1.07)	7.89 ($p < 0.001$)	1 > 2
Technological turbulence	4.4 (0.53)	3.1 (0.94)	8.29 ($p < 0.001$)	1 > 2
Environmental turbulence	4.3 (0.62)	3.0 (1.11)	6.92 ($p < 0.001$)	1 > 2

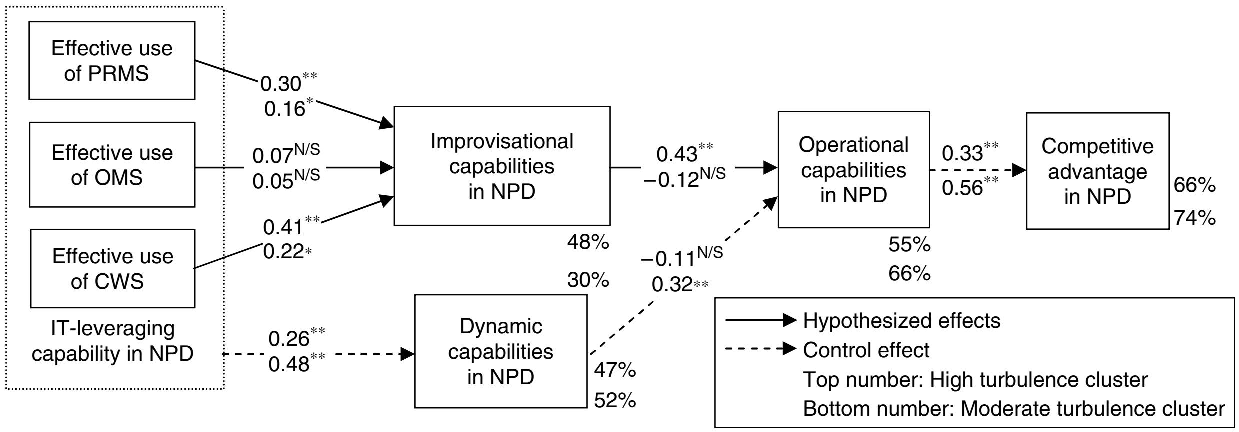
and technological turbulence.[17] The two-step hierarchical cluster analysis resulted in a two cluster solution. As shown in Table 10, Cluster 1 ($n = 53$) (termed "highly turbulent environment") had significantly higher degrees of turbulence than Cluster 2 ($n = 127$) (termed "moderately turbulent" environment). The two-cluster solution was confirmed with the environmental turbulence indicators (bottom row of Table 10).

Figure 5 presents the results for these two distinct clusters, and Table 11 summarizes the control variables.

As Figure 5 attests, dynamic capabilities only have a significant role in *moderately* turbulent

[17] The "moderately turbulent environment" cluster perhaps corresponds to an Eisenhardt and Martin (2000) environment in which dynamic capabilities are expected to be mostly influential. The highly turbulent environment cluster corresponds to Eisenhardt and Martin's *high velocity* environments, where improvisational capabilities are expected to prevail.

Figure 5 PLS Structural Model Results of Highly vs. Moderate Turbulent Environments



Note. Variance explained (R^2) in percentage.
*Significant at $p < 0.05$; **significant at $p < 0.01$; $^{N/S}$nonsignificant.

environments, and improvisational capabilities only have a significant role in *highly* turbulent environments. Although both capabilities have a positive role in operational capabilities in all environments, their role diminishes when the other is included. The stark differences in the PLS coefficients in each cluster ($p < 0.001$) provide strong statistical support for H4. This further supports the negative moderating role of environmental turbulence on the effect of dynamic capabilities (H4). A similar finding occurs for the interaction effects of IT-leveraging capability with environmental turbulence, which are more pronounced for improvisational capabilities than for dynamic capabilities (Figure 5). Taken together, these findings specify the boundaries of the antecedents and consequences of improvisational capabilities and dynamic capabilities in different levels of environmental turbulence, and they also reinforce their distinction (H1). Finally, the tests of mediation (Baron and Kenny 1986) adapted for PLS regression (Pavlou et al. 2007) showed that improvisational and dynamic capabilities fully mediated the effects of the IT systems on competitive advantage.

6. Discussion

6.1. Key Findings

The study has three key findings. First, it demonstrates the empirical distinction between improvisational and dynamic capabilities as two unique and complementary means for building a competitive advantage by reconfiguring existing (outdated) operational capabilities. Second, the study shows that

Table 11 Control Variables on the Principal Constructs

	Highly turbulent environments		Moderately turbulent environments	
Competitive advantage	Cross-functional integration	$b = 0.15, p < 0.10$	Cross-functional integration	$b = 0.22, p < 0.01$
	Firm size	$b = 0.18, p < 0.05$	Firm size	$b = 0.20, p < 0.05$
	Work unit size	$b = 0.13, p < 0.10$	Work unit size	$b = 0.15, p < 0.05$
Operational capabilities	Product innovation type	$b = 0.25, p < 0.05$	Work unit experience	$b = 0.26, p < 0.01$
			Cross-functional integration	$b = 0.21, p < 0.01$
Improvisational capabilities	Product innovation type	$b = 0.25, p < 0.01$	Product innovation type	$b = 0.14, p < 0.05$
	Work unit experience	$b = 0.12, p < 0.10$	Work unit experience	$b = 0.12, p < 0.10$
Dynamic capabilities	Product innovation type	$b = 0.22, p < 0.05$	Product innovation type	$b = 0.17, p < 0.05$
	Work unit experience	$b = 0.13, p < 0.10$	Work unit experience	$b = 0.23, p < 0.01$
	Cross-functional integration	$b = 0.14, p < 0.10$	Cross-functional integration	$b = 0.22, p < 0.01$

Note. Not shown in Figure 6.

the moderating role of environmental turbulence on the effects of improvisational and dynamic capabilities on competitive advantage is complex, and the competitive role of dynamic capabilities diminishes in highly turbulent environments and gives way to improvisational capabilities ("the third hand"). In contrast, the opposite is observed in moderately turbulent environments. Third, the study shows the differential effect of the effective use of three IT systems on improvisational and dynamic capabilities in turbulence. These findings have implications for theory and practice.

6.2. Contributions and Implications for Theory and Practice

6.2.1. Implications for the Nature and Distinction of Improvisational Capabilities. Although the ability to reconfigure operational capabilities in turbulence is referred to as "strategic flexibility," such a generalized catch-all concept does not do justice to the difficulty of addressing environmental turbulence (Bahrami and Evans 2005). Even the more specific view of dynamic capabilities to capture all reconfiguration capabilities may be incomplete (Winter 2003). To better understand how to reconfigure operational capabilities, we need to identify and articulate the specific capabilities that are needed to address different types of environmental turbulence (e.g., storms and waves). This study introduces *improvisational capabilities* as a distinct means for reconfiguring operational capabilities at high levels of turbulence, thus adding another piece to an organization's "capabilities repertoire" for addressing a broad range of turbulent environments.

Although Eisenhardt and Martin (2000) viewed improvisational and dynamic capabilities under a unitary umbrella; however, we believe that their fundamental differences warrant a distinct conceptualization. Variants of those distinctions have been proposed by scholars in information systems, strategy, and supply chain management. For example, Lee et al. (2009), building on the study by Sambamurthy et al. (2003), distinguish between *entrepreneurial agility* (anticipating and being proactive to change) and *adaptive agility* (sensing and reacting to change). Sull (2009) distinguishes between *agility* (the ability to spot and exploit opportunities) and *absorption* (the strength to withstand sudden shifts). Also, in supply chain management, Lee (2004) distinguishes between *adaptability* (evolving for market changes) and *agility* (responding to short-term changes). Each of those variants serves to accentuate a dimensionality that is relevant to the context and purpose of their study. The distinction we articulate between dynamic capabilities and improvisational capabilities is designed to be especially helpful for understanding competitive contexts that have generally high levels of turbulence. This distinction enables us to better understand improvisational capabilities, such as examining its differential effect on competitive advantage in turbulence relative to dynamic capabilities, how different types of IT systems help support improvisational capabilities differently from dynamic capabilities, and how environmental turbulence differently moderates the effects of digital IT systems on these two capabilities.

This study renders support for the notion that improvisational capabilities are an asset and a "third hand"—rather than a failure of planning or a liability. Although a negative link between planning and improvisation has been inferred (Slotegraaf and Dickson 2004), we find a positive link between improvisational and dynamic capabilities. Although reconfiguration must be accomplished with either improvisational capabilities or dynamic capabilities, organizations can exercise both dynamic and improvisational capabilities based on whether planning is possible, necessary, or optimal. Even if dynamic capabilities are more effective in moderately turbulent environments (waves), improvisation capabilities do *not* have a negative impact in moderately turbulent environments. This may be because they are "inexpensive" capabilities that do not require extensive planning, training, or frequent practice (although this may change as we better understand how to systematically develop improvisational capabilities). For managers, this implies that improvisational capabilities are legitimate organizational capabilities that do not necessarily imply failure of planning or a liability and that managers can create the proper conditions to foster improvisational capabilities (Orlikowski and Hofman 1997, Majchrzak et al. 2006). Mendonça (2007) gives several examples of how improvisation can be fostered or induced.

6.2.2. Implications for the "Third-Hand" Role of Improvisational Capabilities in Turbulence. Vera and Crossan (2005) argue that improvisation is a means to manage the tension between exploration (dynamic capabilities) and exploitation (operational capabilities). Similarly, dynamic capabilities have been described as "exploration" capabilities and operational capabilities as "exploitation" capabilities that jointly create the "ambidextrous" organization (Im and Rai 2008). We add to the spirit of these perspectives by proposing improvisational capabilities as "spontaneous" capabilities that operate distinctly as a "third hand," also contributing to the reconfiguration of operational capabilities and organizational change. We have shown that this third hand extends the "ambidexterity" of an organization and is used under certain conditions (extremely high turbulence or "storms") when the two "hands" (dynamic and operational capabilities) can no longer work as well together.

The results show that improvisational capabilities are most valuable in highly turbulent environments, whereas dynamic capabilities dominate in moderately turbulent environments. Improvisation is viewed as useful only in a few narrow contexts (and ineffective or even harmful in others) (Moorman and Miner 1998a), but this study shows that improvisational capabilities may be effective as complements to dynamic capabilities in severe turbulence ("storms").[18] This finding helps answer Weick's (1998) call for understanding the contingencies under which improvisation benefits or harms organizations by specifying the range of environmental turbulence where improvisational capabilities are influential. This finding also has implications for managers who do not have much guidance on being agile in turbulent environments (Majchrzak et al. 2006). Therefore, depending on the degree of environmental turbulence in which a particular work unit operates, this study gives managers some guidance on allocating resources across improvisational, dynamic, and operational capabilities.

6.2.3. Implications for the Role of Different Types of IT Systems on Competitive Advantage. This paper was motivated by the need to understand the role of digital IT systems on competitive advantage in turbulence. Interestingly, the effect of different types of IT systems on improvisational and dynamic capabilities is noticeably different. Thus, we have looked more closely inside the "black box" of IT systems and shown that OMS exert an *insignificant* effect on improvisational capabilities but a *significant* effect on dynamic capabilities, particularly in turbulence. This finding can be explained based on Vera and Crossan (2005), which notes that past memory may impede improvisation. Also, both PRMS and CWS have significant effects on improvisational capabilities, and these effects are reinforced in turbulence; however, the significant effect of OMS on dynamic capabilities is *not* moderated by turbulence. Besides supporting the distinction between improvisational capabilities and dynamic capabilities (H1), these findings shed light on how these two capabilities can be enhanced, or not, by IT.

Our results also suggest that some IT systems may *not* be useful in enhancing improvisational capabilities. Given that OMS focus on project histories, content repositories, knowledge directories, and data warehousing functionalities that give access to past knowledge and organizational memory from past projects, OMS may impede improvisational capabilities that focus on responding to new situations by acting outside past knowledge. Vera and Crossan (2005) found that past knowledge may constrain improvisation by forcing people to rely on past practices that may not relate to the situation at hand. In contrast, OMS enhance dynamic capabilities by taking advantage of existing, situation-specific knowledge from past projects to guide planned reconfiguration.

Although the effect of PRMS and CWS on dynamic capabilities is not reinforced by environmental turbulence, the interaction effects of PRMS and CWS on improvisational capabilities are the most pronounced and explain more variance in improvisational capabilities ($R^2 = 17.4\%$) than their corresponding direct

[18] The finding that improvisational capabilities are more effective in extremely turbulent environments does not *necessarily* imply that *all* organizations thoughtfully engage in improvisation in such turbulent environments. This finding simply implies that those organizations that choose to improvise in such environments and that have developed improvisational capabilities are more likely to enjoy a competitive advantage by matching appropriate capabilities with the environmental context.

effects ($R^2 = 12.3\%$). CWS help spontaneously create situation-specific knowledge to address novel situations through brainstorming that allows diverse ideas to come together quickly, thus enabling collective reactions to environmental "storms." CWS also help create opportunities for mixing and matching past procedures and resources (Mendonça 2007). These results support the enhanced role of IT systems in improvisational capabilities in turbulent environments by enabling real-time awareness of existing resources and synchronized group communication and collaboration. Such unique properties make these systems particularly valuable in highly turbulent environments, explaining not only their direct role in improvisational capabilities, but their major interaction effect in turbulence. These properties of IT systems also explain the relatively weaker interaction effect of IT-leveraging capability on dynamic capabilities, as real-time resource monitoring and synchronized communication have a lesser role in planned reconfiguration. These findings have implications for managers by explaining where to allocate their investments in IT systems, depending on the reconfiguration capabilities they wish to enhance with IT systems.

6.2.4. Implications for NPD. This study extends the NPD literature that has relied on case studies (e.g., Brown and Eisenhardt 1995; Moorman and Miner 1998b, 2001) by demonstrating the positive effect of improvisational capabilities in NPD with a large-scale empirical study. Moreover, this study specifies the range of environmental turbulence that improvisation is likely to be valuable (extreme turbulence or "storms"), still showing that improvisation is not harmful in less turbulent environments. This extends the NPD literature that has assumed that improvisation in low degrees of environmental turbulence could be disruptive (e.g., Moorman and Miner 1998b). Most important, this study contributes to the NPD literature by identifying the particular IT systems in NPD (PRMS and CWS) that are most effective in enhancing improvisational capabilities, particularly in turbulent environments.

6.3. Limitations and Suggestions for Future Research

By showing that IT systems help boost improvisational capabilities, this study sets the stage for answering the call for research on enhancing improvisation and reconfiguration (Eisenhardt and Tabrizi 1995, Winter 2003). To identify the dimensions of improvisational capabilities, the nature of turbulence itself must be understood first (Majchrzak et al. 2006). This study has examined the role of improvisational capabilities in a broader range of turbulence (e.g., "waves" and "storms"), but more research is needed to better understand the multidimensional nature of environmental turbulence (Holsapple and Jin 2007). For example, Bennett and Bennett (2008) discuss several concepts (e.g., emergence, butterfly effect, tipping point, feedback loops, and power laws) that may enhance understanding of environmental turbulence. Accordingly, the nature of environmental turbulence will help us further develop the dimensions of improvisational capabilities. This paper has identified a set of improvisational activities in which NPD work units engage, such as being aware of crises and surprises, identifying existing procedures, collectively brainstorming in real time, spontaneously recombining existing resources, and finding novel solutions. Future research could expand the scope of improvisational activities to help identify a comprehensive set of dimensions of improvisational capabilities and accordingly develop commensurate scales to measure them.

There is also a need to investigate the effects of other types of IT systems on improvisational capabilities. The IT systems examined in this study (PRMS, OMS, CWS) were all specific to the NPD context. There are other functional contexts with other types of IT systems, as well as emerging IT architectures that offer promise for digital competition. There are also emerging IT architectures that have characteristics that appear to be suitable for improvisation in turbulent environments and real-time responsiveness, such as service-oriented, event-driven, and self-learning architectures (El Sawy and Pavlou 2008). As improvisational capabilities become better understood, future research can design dedicated IT functionalities that will specifically focus on enhancing the specific dimensions of improvisational capabilities.

Whereas this study focuses on the antecedent role of IT systems, future research can have a more general set of antecedents of improvisational capabilities, such as economic, social, and cultural factors.

Mendonça (2007) offers examples of environmental factors that may induce improvisational capabilities. There is evidence that there may be cultural effects on improvisation and different cultures may have different planning orientations. For example, improvisation is viewed more virtuously in some countries (El Sherif and El Sawy 1990). Future research could thus examine how to develop improvisational capabilities in different cultures and contexts.

This study shows that improvisation is valuable in highly turbulent environments, but it is important to note that improvisation may be stressful, cannot be exercised all the time, and may not work in chaotic environments. Future research could attempt to identify effective versus noneffective patterns of improvisational actions in novel situations to facilitate their routinization into effective organizational capabilities. Future research may also identify the upper limits to the value potential of improvisational capabilities and when breakdowns may also occur.

Finally, although this study focuses on the improvisational and dynamic capabilities of NPD work units, we have no reason to believe that these capabilities would not generalize to other organizational areas beyond NPD or to the entire organization. Future research could test the generalizability of the proposed model and identify other contingencies that influence IT-enabled competitive advantage at different contexts, units, and levels of analysis.

7. Conclusion

By explaining how improvisational capabilities can help firms engage in competitive (improvisational) actions, this paper contributes to the organizational capabilities and competitive dynamics literatures by showing that improvisation is a unique capability that can be used to launch spontaneous competitive actions to address turbulent environments. Our study thus has implications for the competitive dynamics literature by integrating improvisational capabilities with certain spontaneous competitive actions that have elements of improvisation (intuitive and spontaneous responsiveness). Moreover, our study links the literature on improvisation with the emerging AMC framework to show how organizations engage in effective improvisational actions by being aware of complex market dynamics, becoming motivated to respond in novel conditions, and building the necessary capabilities to engage in effective spontaneous actions with the aid of IT. This has practical implications to the increasingly volatile circumstances in the global economy that require organizations to spontaneously act in novel ways to respond to stormy challenges, such as those imposed by the financial crisis that was triggered in 2008.

The inclusion and dominating role of improvisational capabilities in highly turbulent environments enriches the general model that links IT capabilities with competitive advantage in turbulence (Pavlou and El Sawy 2006) by accounting for another "missing" link in the process by which IT helps build a competitive advantage in turbulence. The effective use of IT systems helps build an IT-enabled competitive advantage in turbulence by enhancing specific reconfiguration capabilities in distinct ways. This study explain how IT systems enhance improvisational capabilities by enhancing the ability to engage in competitive actions. The proposed link between IT systems → improvisational (and dynamic) capabilities → competitive advantage delineates the process by which IT builds a competitive advantage through reconfiguration capabilities, extending the work of Chi et al. (2008b) on how interorganizational systems facilitate competitive actions. A solid understanding of this strategic process with the key mediating capabilities is fundamental in advancing the IT strategy literature, and future research may need to include building on mediating capabilities such as agility (Sambamurthy et al. 2003) and ambidexterity (Im and Rai 2008).

As organizations continue to be increasingly engaged in IT-enabled competitive dynamics in turbulent environments, IT-enabled competitive advantage will continue to capture the attention of information systems and strategy academics and practitioners. Improvisational capabilities add yet another piece to the science of competitiveness literature (Chi et al. 2008a) in an IT-intensive world by identifying the appropriate reconfiguration capabilities needed to address highly turbulent environments with frequent and unexpected storms. We have shown that the road to IT-enabled competitive advantage in turbulence, besides dynamic capabilities (Pavlou and El Sawy 2006), *also* passes through improvisational capabilities that constitute a useful "third hand" when dynamic capabilities and the ambidexterity between dynamic and operational capabilities are no longer effective in extremely turbulent environments. Further research and the advancement of our differentiated understanding of capabilities may reveal that there is a fourth hand and perhaps even a fifth hand that may emerge in other types of environmental conditions, but we believe that this study makes one small step toward a better understanding of how digital IT systems influence competitive dynamics in a broader range of environmental turbulence.

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