Understanding the Elusive Black Box of Dynamic Capabilities

Paul A. Pavlou†
Fox School of Business, Temple University, Philadelphia, PA 19122, e-mail: pavlou@temple.edu

Omar A. El Sawy
Marshall School of Business, University of Southern California, Los Angeles, CA 90089, e-mail: elsawy@usc.edu

ABSTRACT

A major challenge for managers in turbulent environments is to make sound decisions quickly. Dynamic capabilities have been proposed as a means for addressing turbulent environments by helping managers extend, modify, and reconfigure existing operational capabilities into new ones that better match the environment. However, because dynamic capabilities have been viewed as an elusive black box, it is difficult for managers to make sound decisions in turbulent environments if they cannot effectively measure dynamic capabilities. Therefore, we first seek to propose a measurable model of dynamic capabilities by conceptualizing, operationalizing, and measuring dynamic capabilities. Specifically, drawing upon the dynamic capabilities literature, we identify a set of capabilities—sensing the environment, learning, coordinating, and integrating—that help reconfigure existing operational capabilities into new ones that better match the environment. Second, we propose a structural model where dynamic capabilities influence performance by reconfiguring existing operational capabilities in the context of new product development (NPD). Data from 180 NPD units support both the measurable model of dynamic capabilities and also the structural model by which dynamic capabilities influence performance in NPD by reconfiguring operational capabilities, particularly in higher levels of environmental turbulence. The study’s implications for managerial decision making in turbulent environments by capturing the elusive black box of dynamic capabilities are discussed.


INTRODUCTION

Decision making in turbulent environments is challenging because managers must decide and act rapidly (Carlsson & El Sawy, 2008). In turbulent environments, dynamic capabilities—“the ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments”—(Teece,
Pisano, & Shuen, 1997, p. 517) have been viewed as viable means for managing in turbulent environments. However, dynamic capabilities have been described mostly as abstract concepts or an elusive “black box.” The literature viewed dynamic capabilities as hidden or invisible (Itami, 1987), complex and tacit (Dierickx & Cool, 1989), difficult to observe (Simonin, 1999), and causally ambiguous (Williamson, 1999). Zahra, Sapienza, and Davidsson (2006) note several inconsistencies in the usage of the dynamic capabilities concept. Dynamic capabilities have also been criticized for their lack of precise definition, empirical grounding, and measurement (Williamson, 1999), and attempts to measure dynamic capabilities have used distant proxies (e.g., Henderson & Cockburn, 1994). Arend and Bromiley (2009) note a plethora of proxies, often unusual, for dynamic capabilities. Nerkar and Roberts (2004) argue: “absent the ability to measure these (often intangible) assets [dynamic capabilities] with any degree of precision, we assume that they develop as a function of a firm’s accumulated experience” (p. 781). Zahra et al. (2006) suggest that dynamic capabilities are mostly empirically identified ex post. Galunic and Eisenhardt (2001) further argue that the existence of dynamic capabilities is often assumed without specifying their exact components. Given the difficulty in articulating the characteristics and measurement of dynamic capabilities, Winter (2003, p. 991) cites critics who even argued that dynamic capabilities are “born, not made” and challenged whether they even exist in practice. Others have argued that dynamic capabilities are tautologically linked to performance (Priem & Butler, 2001; Williamson, 1999). Finally, there is a notion that dynamic capabilities may not even be amenable to managerial action (Grant, 1996), implying that managers may not even recognize the existence of dynamic capabilities in practice. Concluding their review of the limitations of the dynamic capabilities view, Arend and Bromiley (2009) argue that there is an urgent need for a coherent theory and model for dynamic capabilities.

The poor understanding of dynamic capabilities and the lack of a measurable model makes it difficult to study how dynamic capabilities can be used in actionable managerial decision making. To help managers make decisions in turbulent environments with the aid of dynamic capabilities, our first objective it to open the black box of dynamic capabilities to propose a measurable model of dynamic capabilities by conceptualizing, operationalizing, and measuring dynamic capabilities. Such a measurable model would enable managers to rely upon dynamic capabilities to reconfigure operational capabilities to enhance the quality of their decision making in turbulent environments.

Second, to examine the performance effects of dynamic capabilities in turbulent environments, it is necessary to understand their links with operational capabilities. By showing the positive effect of dynamic capabilities on reconfiguring operational capabilities to match turbulent environments, this study aims to overcome the criticism that dynamic capabilities have a positive bias and are tautologically linked to performance (e.g., Williamson, 1999; Priem & Butler, 2001; Zott, 2003). Moreover, to specify the boundaries of dynamic capabilities, the study examines the effects of dynamic capabilities on operational capabilities in different levels of environmental turbulence. Our second objective is thus to propose a structural model by which dynamic capabilities shape performance by reconfiguring existing operational capabilities in turbulent environments.
CONCEPTUAL DEVELOPMENT

Conceptualization, Operationalization, and Measurement of Dynamic Capabilities

Origins and scope of dynamic capabilities

The dynamic capabilities view originates in spirit from Schumpeter’s (1934) innovation-based competition where competitive advantage is based on the creative destruction of existing resources and novel recombination into new operational capabilities. These ideas were further developed in the literature, such as architectural innovation (Abernathy & Clark, 1986), configuration competence (Henderson & Cockburn, 1994), and combinative capabilities (Kogut & Zander, 1992). Extending these studies, Teece et al. (1997) developed the notion of dynamic capabilities, and their seminal paper is considered the most influential source on dynamic capabilities, together with a recent framework of dynamic capabilities (Teece, 2007). Teece and colleagues (Teece et al., 1997; Teece, 2007) see competitive advantage in turbulent environments as a function of dynamic capabilities rather than competitive positioning or industry conflict. They used the term “dynamic” to reflect “the capacity to renew competences so as to achieve congruence with the changing environment” (p. 515). The dynamic capabilities view follows the resource-based view (RBV) (Makadok, 2001), whereas RBV emphasizes resource picking (selecting resource combinations), dynamic capabilities stress resource renewal (reconfiguring resources into new combinations of operational capabilities). Because managers must regularly make decisions on how to renew existing operational capabilities into new ones that better match the changing environment, dynamic capabilities represent an important challenge for managers in their quest to achieve a sustainable competitive advantage (Grewal & Slotegraaf, 2007). Accordingly, to better understand dynamic capabilities, it is important to recognize their distinction from operational capabilities that they seek to reconfigure.

Dynamic capabilities versus operational capabilities

It is imperative to distinguish between dynamic capabilities and operational capabilities. Capabilities are collections of routines (Winter, 2003), and they describe how effectively routines are executed relative to the competition (Nelson &
Winter, 1982). According to Winter, a capability is described as a high-level routine (or a collection of routines). A routine is a “behavior that is learned, highly patterned, repetitious, or quasi-repetitious, founded in part in tacit knowledge—and the specificity of objectives” (p. 991). Although both capabilities are collections of routines, dynamic capabilities describe the ability to reconfigure and change, whereas operational capabilities denote the ability to “make a daily living” (Winter, 2003, p. 991). Operational capabilities were termed by Winter as ordinary or “zero-order” capabilities whose goal is to “earn a living by producing and selling the same product, on the same scale and the same customer population” (p. 992). Operational capabilities are herein defined as the ability to execute day-to-day activities. On the other hand, dynamic capabilities are termed “first-order” capabilities whose goal is to change the product, the production process, the scale, or the markets (customers) served (Winter, 2003). Collis (1994) notes that dynamic capabilities govern the change of operational capabilities by reconfiguring them to keep them relevant to the changing environment. Using March’s (1991) exploration-exploitation view, dynamic capabilities would correspond to the exploration of new opportunities, whereas operational capabilities would correspond to the efficient exploitation of existing resources. Following Winter (2003) and Teece (2007), we define dynamic capabilities as those capabilities that help units extend, modify, and reconfigure their existing operational capabilities into new ones that better match the changing environment. Applied to NPD, whereas dynamic capabilities would focus on selecting the product to match the changing environment, operational capabilities would focus on executing the day-to-day activities needed to actually develop the product.

Identification of proposed set of dynamic capabilities

Extending the work of Teece and his colleagues (Teece et al., 1997; Teece, 2007) from an abstract view of firm-level aggregate strategy to a more tangible view of dynamic capabilities at the managerial decision-making level, we seek to identify, conceptualize, operationalize, and measure a measurable model with a set of identifiable and specific components of dynamic capabilities.

To identify the proposed set of dynamic capabilities, we relied on Eisenhardt and Martin (2000) who note: “dynamic capabilities actually consist of identifiable and specific routines that often have been the subject of extensive empirical research in their own right” (p. 1107). Extending this logic and drawing upon the strategic management and decision sciences literatures, we aim at proposing an identifiable and parsimonious set of dynamic capabilities. Our starting point is Teece et al.’s (1997) (reconfiguring, learning, integrating, and coordinating) and Teece’s (2007) (sensing the environment to seize opportunities and reconfigure assets) distinct capabilities. Because different labels have been used in the literature to refer to similar capabilities, or similar labels for different capabilities, we reconciled the various labels and meanings from the literature, and grouped them under a parsimonious set to reflect Teece et al.’s (1997) and Teece’s (2007) conceptualization, our own interpretation of the literature, and relevance to NPD business units. Specifically, dynamic capabilities are viewed as tools that enable the reconfiguration of existing operational capabilities (Galunic & Eisenhardt, 2001).
Reconfiguring operational capabilities and deploying new ones to address turbulent environments is the ultimate goal of dynamic capabilities that seek to achieve evolutionary fitness and prevent rigidities (Teece, 2007). Reconfiguration refers to the appropriateness (Galunic & Rodan, 1998), timeliness (Zott, 2003), and efficiency (Kogut & Zander, 1996) by which operational capabilities are reconfigured to fit the environment. Reconfiguration is markedly relevant in NPD where new products are the outcome of reconfigured operational capabilities (Henderson & Clark, 1990). The proposed dynamic capabilities that are proposed as tools for reconfiguring existing operational capabilities are: (i) sensing; (ii) learning, (iii) integration, and (iv) coordination capabilities. Those are graphically presented in Figure 1, which briefly describes each capability, and it also explains the logic by which the proposed dynamic capabilities help managers reconfigure the operational capabilities of their NPD units into new, more relevant ones that better match the environment. The proposed dynamic capabilities are neither exhaustive, nor sufficient for reconfiguration to occur, but they are posited as important enablers of the ability to reconfigure operational capabilities, as described in detail below.

For simplicity of illustration, the proposed framework (Figure 1) presents the four dynamic capabilities as interacting in a sequential logic to reconfigure existing operational capabilities. However, there are reciprocal relationships among these capabilities, which are theorized in the description of the proposed dynamic capabilities.

**Sensing capability**

Reconfiguration requires a surveillance of market trends and new technologies to sense and seize opportunities. Teece et al. (1997, p. 521) note: “The ability to calibrate the requirements for change and to effectuate the necessary adjustments would appear to depend on the ability to scan the environment, to evaluate markets and competitors, and to quickly accomplish reconfiguration ahead of competition.” Sensing capability is defined as the ability to spot, interpret, and pursue opportunities.
opportunities in the environment. In NPD, business units must sense the environment to gather market intelligence on market needs, competitor moves, and new technologies in order for managers to identify new product opportunities, and decide to engage in exploratory early-stage research activities to pursue these opportunities with new product prototypes.

The three basic routines of the sensing capability are: (i) generating market intelligence (Galunic & Rodan, 1998), (ii) disseminating market intelligence (Kogut & Zander, 1996), and (iii) responding to market intelligence (Teece, 2007). These routines are related to kindred routines in the dynamic capabilities literature. Generating market intelligence relates to identifying customer needs (Teece, 2007), being responsive to market trends (Amit & Schoemaker, 1993), identifying market opportunities (Day, 1994), recognizing rigidities (Sinkula, 1994), and detecting resource combinations (Galunic & Rodan, 1998). Disseminating market intelligence relates to interpreting market intelligence (Kogut & Zander, 1996), making sense of events and developments, and exploring new opportunities (Teece, 2007). Responding to market intelligence also relates to initiating plans to capitalize on market intelligence (D'Aveni, 1994), and pursuing specific market segments with plans to seize the new market opportunities (Teece, 2007).

The sensing capability of NPD units is proposed to enable the reconfiguration of their existing operational capabilities. First, generating market intelligence raises the NPD unit’s potential to identify new market opportunities for reconfiguration (Zahra & George, 2002). Second, disseminating market intelligence helps NPD units to achieve responsiveness to customer needs (Day, 1994). Third, responding to market intelligence promotes product innovation and enables NPD units to explore emergent opportunities for new products that better meet customer needs (Jaworski & Kohli, 1993).

**Learning capability**

Once a market opportunity is identified, it must be addressed with new products, which require a decision to revamp existing operational capabilities with learning, and new knowledge and skills (Teece, 2007). For NPD units to take advantage of market opportunities in a changing environment, they must engage in learning to find new solutions, create new knowledge, and reconfigure existing operational NPD capabilities to develop new products. There is a reciprocal two-way relationship between sensing and learning capabilities because learning enhances the ability of NPD units to detect new opportunities (Cohen & Levinthal, 1990; Zahra & George, 2002). Sensing and learning capabilities are distinct capabilities because sensing focuses on gathering new market intelligence, and learning focuses on using market intelligence to create new knowledge (Hurley & Hult, 1998).

Learning capability is defined as the ability to revamp existing operational capabilities with new knowledge. According to Zahra and George (2002) who developed absorptive capacity (learning) as a dynamic capability, the four underlying routines of the proposed learning capability are acquiring, assimilating, transforming, and exploiting knowledge. These routines relate to kindred terms in the dynamic capabilities literature. First, acquiring knowledge relates to obtaining
new knowledge (Cohen & Levinthal, 1990). Second, assimilating knowledge relates to knowledge articulation (Zander & Kogut, 1995) and knowledge brokering (Eisenhardt & Martin, 2000). Third, transforming knowledge relates to innovative problem-solving (Iansiti & Clark, 1994), brainstorming (Pisano, 1994), and creative new thinking (Henderson & Cockburn, 1994). Finally, exploiting knowledge relates to pursuing new initiatives (Van den Bosch, Volberda, & De Boer, 1999), seizing opportunities with learning (Teece, 2007), and revamping operational capabilities (Grant, 1996).

Cohen and Levinthal (1990, p. 131) suggest that learning helps groups become more proactive by enhancing their “creative capacity.” Van den Bosch et al. (1999) further argue that learning facilitates reconfiguration and innovation. Therefore, learning is proposed as an enabler of reconfiguration by helping revamp existing operational capabilities (Zollo & Winter, 2002).

**Integrating capability**

Reconfiguration relies on integrating new resources, and assets (Galunic & Eisenhardt, 2001). This is because the reconfiguration of existing operational capabilities requires a collective logic and shared interaction patterns (Okhuysen & Eisenhardt, 2002). Because new knowledge created by learning is mostly owned by individuals, it must be integrated to a collective level (Teece, 1982). In the NPD context, because operational capabilities are supra-individual and do not reside in any specific individual, NPD units must integrate their individual knowledge and patterns of interaction into a collective system to deploy the new configurations of operational capabilities.

Integrating capability is defined as the ability to combine individual knowledge into the unit’s new operational capabilities. Its routines—contribution, representation, and interrelation of individual input to the collective business unit—are closely related to the dynamic capabilities literature. Specifically, contribution relates to disseminating individual input within the business unit (Okhuysen & Eisenhardt, 2002). Representation relates to visualizing how people fit in, how other people act, and how the unit’s activities fit together (Crowston & Kammerer, 1998). Interrelation relates to integrating individual inputs within a unit to hone the reconfigured operational capabilities by executing a collective activity (Helfat & Peteraf, 2003).

Integrating capability is proposed to facilitate reconfiguration through its three basic routines. First, contribution to the unit helps collect and combine individual inputs. Second, representation builds a shared understanding, creates a common ground, and develops new perceptual schema (Weick & Roberts, 1993). Third, because reconfiguration requires a new logic of collective interaction, interrelation helps the routinization of the reconfigured operational capabilities (Okhuysen & Eisenhardt, 2002). Weick and Roberts (1993, p. 377) argue that groups with more integrated capabilities can better react in novel situations, whereas Zollo and Winter (2002, p. 340) view dynamic capability as a collective activity by arguing that reconfiguring in a disjointed way does not even exercise a dynamic capability. Finally, Teece (2007) views the integration of knowledge as a foundation of dynamic capabilities.
Coordinating capability

Because the new configurations of operational capabilities require effective coordination of tasks and resources and synchronization of activities (Iansiti & Clark, 1994; Helfat & Peteraf, 2003), coordinating capability enables reconfiguration by administering tasks, activities, and resources to deploy the reconfigured operational capabilities. Coordinating capability is defined as the ability to orchestrate and deploy tasks, resources, and activities in the new operational capabilities. The basic routines of coordinating capability also draw upon the dynamic capabilities literature, namely assigning resources to tasks (Helfat & Peteraf, 2003), appointing the right person to the right task (Eisenhardt & Brown, 1999), identifying complementarities and synergies among tasks and resources (Eisenhardt & Galunic, 2000), and orchestrating collective activities (Henderson, 1994).

Although the integrating capability is positively associated with the coordinating capability because coordination is enhanced by a shared language (Galunic & Eisenhardt, 2001), the integrating and coordinating capabilities are theoretically and empirically distinct (Kogut & Zander, 1996). Although coordination focuses on orchestrating individual tasks and activities, integration focuses on building an overall collective sense-making and understanding (Crowston & Kammerer, 1998).

Coordinating capability is proposed to facilitate the reconfiguration of operational capabilities. First, it enables NPD units to recognize, assemble, and allocate resources (Collis, 1994) by facilitating the dissemination of market intelligence across the unit (Vorhies & Harker, 2000). Second, coordinating capability helps NPD units assign the right person to the right task (Eisenhardt & Brown, 1999). Third, coordinating capability helps NPD units better synchronize their tasks and activities (Helfat & Peteraf, 2003).

Teece et al. (1997) argue “[dynamic] capability is embedded in distinct ways of coordinating” (p. 519). Teece (2007, p. 1338) also argued: “In short, both innovation and reconfiguration may necessitate cospecialized assets being combined by management in order for (systemic) innovation to occur.” Okhuyzen and Eisenhardt (2002, p. 382) argue that effective allocation of resources enhances the flexibility of NPD units by helping assign the right person to the right task, an essential element of successful reconfiguration (Eisenhardt & Brown, 1999). Also, Quinn and Dutton (2005) noted: “coordination is the process people use to create, adapt, and re-create organizations” (p. 36). Thus, coordinating capability helps implement and deploy the reconfigured operational capabilities.

Table 1 summarizes the definitions of the proposed dynamic capabilities, and it also shows that many of the routines discussed in the dynamic capabilities literature can be categorized under each capability. This suggests that our proposed set of dynamic capabilities is closely linked to the dynamic capabilities literature through their underlying routines. This is consistent with Brown and Eisenhardt (1997) who view dynamic capabilities as complex combinations of simpler routines.
Table 1: Definition of proposed capabilities and links to the dynamic capabilities literature.

<table>
<thead>
<tr>
<th>Capability</th>
<th>Definition</th>
<th>Basic Routines</th>
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<tbody>
<tr>
<td>Sensing capability</td>
<td>The ability to spot, interpret, and pursue opportunities in the environment.</td>
<td>• Generating market intelligence (Galunic &amp; Rodan, 1998)</td>
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<td></td>
<td></td>
<td>• Disseminating market intelligence (Kogut &amp; Zander, 1996)</td>
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<td></td>
<td></td>
<td>• Responding to market intelligence (Teece, 2007)</td>
</tr>
<tr>
<td>Learning capability</td>
<td>The ability to revamp existing operational capabilities with new knowledge.</td>
<td>• Acquiring, assimilating, transforming, and exploiting knowledge (Zahra &amp; George, 2002)</td>
</tr>
<tr>
<td>Integrating capability</td>
<td>The ability to embed new knowledge into the new operational capabilities by creating a shared understanding and collective sense-making.</td>
<td>• Contributing individual knowledge to the group (Okhuysen &amp; Eisenhardt, 2002)</td>
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<td></td>
<td></td>
<td>• Representation of individual &amp; group knowledge (Crowston &amp; Kammerer, 1998)</td>
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<td></td>
<td></td>
<td>• Interrelation of diverse knowledge inputs to the collective system (Grant, 1996)</td>
</tr>
<tr>
<td>Coordinating capability</td>
<td>The ability to orchestrate and deploy tasks, resources, and activities in the new operational capabilities.</td>
<td>• Assigning resources to tasks (Helfat &amp; Peteraf, 2003)</td>
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<td></td>
<td></td>
<td>• Appointing right persons to right tasks (Eisenhardt &amp; Brown, 1999)</td>
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<tr>
<td></td>
<td></td>
<td>• Identifying synergies among tasks, activities, and resources (Eisenhardt &amp; Galunic, 2000)</td>
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<td></td>
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<td>• Orchestrating activities (Henderson, 1994)</td>
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The Effects of Dynamic Capabilities on Operational Capabilities in Turbulence

Although dynamic capabilities have certain commonalities (Eisenhardt & Martin, 2000), they are likely to differ across business units because their complex nature makes them difficult to imitate (Galunic & Eisenhardt, 2001). Due to their inherent complexity (Collis, 1994), path dependence (Teece et al., 1997), and causal ambiguity (Lippman & Rumelt, 1982), dynamic capabilities are herein proposed to differentially affect performance. However, the exact mechanisms by which dynamic capabilities influence performance are still not very well understood (Zott, 2003), and dynamic capabilities are often confounded with their effects. This is why dynamic capabilities have been criticized as being tautologically linked to performance (Williamson, 1999). Therefore, to distinguish dynamic capabilities from their effects on operational capabilities and performance, we propose a
Figure 2: The structural model of the effects of dynamic capabilities in environmental turbulence.

![Structural Model Diagram](image)

The structural model where the effect of dynamic capabilities on performance in NPD is mediated by operational capabilities and moderated by environmental turbulence (Figure 2).

In the NPD literature, performance in NPD is composed of two dimensions of product success (e.g., Clark & Fujimoto, 1991; Griffin, 1997; Kusunoki, Nonaka, & Nagata, 1998): (i) product effectiveness (product quality, innovativeness) and (ii) process efficiency (time to market at a low cost). Given the long-held trade-off in NPD between product quality, timeliness, and cost (Cohen, Eliashberg, & Ho, 1996), we view NPD performance as the achievement of product effectiveness and process efficiency. This is consistent with the marketing literature that suggests that customers seek quality products in a timely fashion and at a low price (Vorhies & Harker, 2000). This is also consistent with the NPD literature that empirically shows that successful new products offer a favorable combination of high product quality, timeliness, and low cost (Atuahene-Gima & Li, 2004).

The primary operational capabilities in NPD needed for developing new products are technical, customer, and managerial (Danneels, 2002). First, technical capability is the ability to physically develop new products by understanding product technologies, evaluating the feasibility of product designs, testing prototypes, and assessing technical specifications (Pisano, 1994). Second, customer capability is the ability to market the new products to customers through advertising, distributing, pricing, selling, and order entry (Day, 1994). Third, managerial capability is the ability to administer activities at the operational level of the NPD unit by monitoring and reporting progress, designing incentives, and managing conflicts (Danneels, 2002). These three capabilities comprise the primary operational NPD capabilities of NPD business units.

New products are essentially the manifestation of an NPD unit’s operational capabilities (Teece, 1982), and successful new products are directly dependent on operational NPD capabilities (Clark & Fujimoto, 1991). Operational capabilities, however, are not product specific, but they are the platform for developing any new products (Griffin, 1997). Operational NPD capabilities offer the potential to build technically sophisticated new products that better meet customer needs with the aid of management (Song, Droge, Hanvanich, & Calantone, 2005). In contrast, outdated operational NPD capabilities that do not match market needs and do not follow technological developments—termed “rigidities” by Leonard-Barton (1992)—result in poor process efficiency and low product effectiveness,
and inferior new products. Thus, NPD performance is directly dependent upon operational capabilities.

**The effect of dynamic capabilities on operational NPD capabilities**

The value of dynamic capabilities is in the new configurations of operational capabilities they help reconfigure (Eisenhardt & Martin, 2000). Although dynamic capabilities can reconfigure operational capabilities in various directions (Helfat & Peteraf, 2003), we focus on the appropriateness (how well the configurations of operational capabilities match the environment), timeliness (how quickly the operational capabilities are reconfigured into new configurations), and efficiency (how economical and cost-effective the reconfiguration is) by which the existing operational NPD capabilities are reconfigured into new ones that better match the environment.

First, by having the dynamic capability to generate, disseminate, and respond to market intelligence (sensing capability), NPD units are more likely to quickly introduce new products that better match customer needs (technical capability), thus making it easier to sell such products (customer capability). Second, by quickly generating new knowledge on technological breakthroughs (learning capability), NPD business units are more likely to develop technologically sophisticated new products (technical capability). Third, by being effective in integrating knowledge and interaction patterns (integrating capability), and in orchestrating resources, tasks, and activities (coordinating capability), NPD units are more likely to administer the new NPD activities by monitoring progress, designing incentives, and managing internal conflicts (managerial capability). Thus, dynamic capabilities that are responsible for selecting the new products are proposed to be positively associated with operational NPD capabilities that are responsible for physically building, managing, and selling new products. Empirical evidence suggests that dynamic capabilities are associated with high product quality and fast cycle time (Henderson & Clark, 1990; Iansiti & Clark, 1994). Integrating these arguments, we hypothesize:

**H1: An NPD unit’s dynamic capabilities are positively associated with its operational capabilities.**

H1 suggests that dynamic capabilities indirectly influence performance by reconfiguring existing operational capabilities into superior ones that better match the changing environment. Although operational capabilities have a direct effect on performance at any “snapshot” in time, interpreting H1 from a longitudinal standpoint, dynamic capabilities have a longitudinal effect on performance over time by reconfiguring new operational capabilities that offer a series of new products that better match the environment. This logic is consistent with Teece et al. (1997) who argue that new products at any given point in time depend on operational capabilities in NPD, which depend on dynamic capabilities from a longitudinal standpoint. Collis (1994) also explains that dynamic capabilities supersede operational capabilities over time. The proposed structural model (Figure 2) thus views dynamic capabilities independent of performance, overcoming the tautological criticism of the dynamic capabilities view (Williamson, 1999).
Dynamic capabilities and operational capabilities in turbulent environments

The proposed effect of dynamic capabilities on operational capabilities is proposed to be moderated by the level of environmental turbulence, which is defined in terms of the frequency and amplitude of change in the environment and general conditions of uncertainty (Duncan, 1972). In NPD, environmental turbulence consists of two primary sources: (i) market turbulence—uncertainty in market demands and competitor moves; and (ii) technological turbulence—frequency of technical breakthroughs (Jap, 2001).

Turbulent environments spawn new opportunities (Sull, 2009; Van den Bosch et al., 1999), thus creating incentives to employ dynamic capabilities to reconfigure existing operational capabilities to pursue new opportunities. Because turbulent environments create a discrepancy between existing and ideal operational capabilities (Fredrickson & Mitchell, 1984), the need for reconfiguration enhances the value of dynamic capabilities. Teece et al. (1997) argue that there is great value in the ability to reconfigure resources in turbulent environments, whereas Rindova and Kotha (2001) argue that turbulent environments make it more likely to reconfigure operational capabilities. Also, rigidities act as alerts (Zahra & George, 2002), forcing NPD business units to take advantage of dynamic capabilities to reconfigure their rigid and outdated operational capabilities.

The moderating role of environmental turbulence is also formally supported by options theory. An option is acquired with a partial investment, and the holder reserves the right to strike the option if the opportunity arises (Sambamurthy, Bharadwaj, & Grover, 2003). Dynamic capabilities can be viewed as options (Kogut & Zander, 1992; Moorman & Slotegraaf, 1999), offering the ability to pursue new market opportunities that the environment creates. The higher the degree of environmental turbulence, the more likely these options will become valuable because more opportunities are likely to emerge. Even if options are costly, NPD units that have the option to reconfigure their existing operational NPD capabilities are more likely to end up with operational capabilities that match the environment. On the other hand, less turbulent environments are less likely to create opportunities for reconfiguring existing operational capabilities, and investments in such options without the occasion to exercise the dynamic capabilities may end up having little or even no value, while they are likely to carry a cost burden (Winter, 2003, p. 993).

Applied to NPD, environmental turbulence enhances the value potential of new products (Griffin, 1997). Dynamic capabilities thus become more valuable in turbulent environments where NPD units need to reconfigure their existing operational NPD capabilities to build new products that better match the environment. Environmental turbulence is expected to negatively moderate the positive effect of operational capabilities on performance (Pavlou & El Sawy, 2006). This is because operational capabilities help achieve process efficiencies in developing a given product. However, turbulent environments erode the value potential of existing products due to changes in market needs, technologies, and rival products (Danneels, 2002). Thus, operational capabilities may become rigidities due to inertia and unwillingness to change (Leonard-Barton, 1992). Because operational capabilities require a costly, time consuming, and often irreversible configuration of existing resources, their frequent reconfiguration is likely to disrupt their efficiency.
Thus, the more turbulent the environment is, the more likely the operational capabilities will become rigid. In contrast, less turbulent environments favor more disciplined decision making (Brown & Eisenhardt, 1997), and they reward the efficient exploitation of operational capabilities. Thus, environmental turbulence is expected to reduce the value potential of existing operational NPD capabilities on performance in NPD. Consequently, we hypothesize:

\[ H2: \text{The positive relationship between an NPD unit’s dynamic capabilities and its operational capabilities is positively moderated (reinforced) by environmental turbulence.} \]

**MEASUREMENT DEVELOPMENT**

Wherever possible, measurement items were adapted from existing scales. For new measures, standard scale development procedures were followed that helped establish the face validity and content validity for the new measures. All measures were adapted to the study’s unit of analysis (NPD business units), and they were phrased relative to the competition (Appendix A).

The study’s unit of analysis is the NPD unit, which may be either intra- or interfirm consistent with De Boer et al. (1999). Following the relational view (Dyer & Singh, 1998) even if interfirm NPD units are formed through a partnership among firms, they are distinct entities on their own right that assume their own trajectory (Song et al., 2005). D’Adderio (2001) explains how resources are integrated across firm boundaries, and Ettlie and Pavlou (2006) and Lane and Lubatkin (1998) show that interfirm partnerships have their own distinct capabilities.

**Dynamic capabilities**

Extending Ettlie and Pavlou (2006) and Pavlou and El Sawy (2006), the proposed set of dynamic capabilities was captured with a formative model (Figure 3). The relationship between first- and second-order constructs can be either reflective or formative in nature (Edwards, 2000). Reflective ones assume that the second-order factor “causes” the first-order factors. Formative ones assume that the second-order factor is “caused” by each of the first-order factors where each factor represents a unique input. The model posits formative indicators for the second-order latent reconfiguration capability and reflective indicators for the first-order measurable capabilities.

Because dynamic capabilities are abstract, intangible, and difficult to describe, they are modeled with a second-order model that is formed by the proposed

**Figure 3:** The proposed measurement model of dynamic capabilities.
four dynamic capabilities that are measurable. As each first-order dynamic capability is posited to “form” or enable reconfiguration, a formative second-order model is more appropriate than a reflective model. A reflective model would imply that reconfiguration “reflects” or causes the four first-order dynamic capabilities. As with all models, the proposed simple formative model of dynamic capabilities is an abstraction from reality and cannot capture the complexity of dynamic capabilities. Yet, it allows the direct measurement of dynamic capabilities through the first-order measurable constructs. The proposed formative model is consistent with Diamantopoulos and Winklhofer’s (2001) guidelines. These principles are: (i) specifying the content domain of the second- and first-order constructs, (ii) proposing the effects of the first-order on the second-order construct, (iii) specifying the relationships and distinctions among the first-order constructs, and (iv) proposing the role of the second-order construct (dynamic capabilities) on the study’s dependent variables (NPD performance).

Formative models must maintain theoretical distinction among their first-order constructs so that each construct contributes a unique component to the second-order construct. As explained earlier, each of the four dynamic capabilities is distinct from each other with each of the four capabilities offering a unique component to the overall ability to reconfigure existing operational capabilities into new ones. The resulting formative model of dynamic capabilities is a measurable model that can be readily used to capture dynamic capabilities through the four underlying components.

Sensing capability captures the generation, dissemination, and responsiveness to market intelligence (Jaworski & Kohli, 1993). Learning capability captures the acquisition, assimilation, transformation, and exploitation of knowledge (Cohen & Levinthal, 1990; Zahra & George, 2002). Coordinating capability captures resource allocation, task assignment, and synchronization (Crowston, 1997). Integrating capability captures the contribution, representation, and interrelation of individual input to the entire business unit (Weick & Roberts, 1993).

For identification purposes, dynamic capabilities were also measured with two direct indicator items (Appendix A) that capture the potential for reconfiguration. The purpose of measuring second-order constructs with (direct) indicator items is to test that the indirect measurement through the first-order dynamic capabilities is also consistent with their indicator items (Figure 3). All measurement items of dynamic capabilities are shown in Appendix A.

**Operational NPD capabilities**

To operationalize operational capabilities in NPD, a formative second-order model (Figure 4) is proposed. A formative model is deemed more appropriate than a reflective model to represent operational capabilities in NPD because the three proposed operational capabilities are complementary to each other (Nerkar & Roberts, 2004), and each capability contributes a unique component to the development of new products (Song et al., 2005).

As shown in Appendix A, customer and technical capabilities were measured by following Song and Parry (1997), whereas managerial capability was measured following Sethi, Smith, and Park (2001). Two reflective indicator items were used
to measure aggregate operational NPD capability (Vorhies & Harker, 2000). These indicator items tested whether the proposed customer, technical, and managerial capabilities jointly span the domain of operational NPD capability.

**NPD performance**

Overall NPD performance is operationalized with a second-order formative model formed by process efficiency and product effectiveness (Figure 5). This view places different weights on the two dimensions, consistent with the logic that firms often focus on one dimension over the other. Still, firms cannot place excessive emphasis on any one dimension due to the risk of being left behind by competitors that focus on both (Sethi, 2000). The correlation between product effectiveness and process efficiency was $r = .16 (p = .049)$, which is not particularly high, supporting the trade-off (Clark & Fujimoto, 1991). Process efficiency and product effectiveness were measured following Kusunoki, Nonaka, and Nagata (1998) and Atuahene-Gima and Li (2004). Because archival performance sources are unavailable for NPD business units, two reflective indicator items for overall NPD performance were measured (Jap, 2001).

Despite the use of perceptual scales for NPD performance given the lack of archival data, subjective scales have their own merits because they permit meaningful comparisons across firms (Song et al., 2005), whereas objective scales do not have a high level of specificity in terms of industry, time horizon, and economic conditions (Song & Parry, 1997).

**Environmental turbulence in NPD**

Environmental turbulence was also modeled as a formative second-order model (Figure 6) with market and technological turbulence as formative constructs. Market and technological turbulence were measured following Jaworski and Kohli (1993) to capture the pace of changes in customer needs and technological
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Figure 6: The proposed measurement model of environmental turbulence.

Table 2: Control variables.

New product development (NPD) unit cross-functional integration: This construct describes the quality of interaction in the NPD unit’s functional areas, which was shown in the literature to influence NPD success (Song & Parry, 1997). It was measured with three items following Song and Parry (1997), and it was controlled for its effect on performance, dynamic capabilities, and operational capabilities in NPD.

NPD unit experience: Experience in NPD measures how many years the unit has been working together (Song & Parry, 1997), and it is controlled for its effect on performance, dynamic capabilities, and operational capabilities in NPD.

Business unit innovation type: NPD projects differ in terms of their innovation type, ranging from routine engineering of existing products, to building incremental new products, to creating radically new products. The innovation type of the NPD unit is controlled for its impact on dynamic capabilities and performance.

Business unit size: The group’s number of NPD workers was also controlled for.

Business unit functional areas: The number of functional areas (e.g., marketing, research and development, engineering) of the NPD unit was controlled for its effect on NPD performance.

Business unit manager: Whether the group’s manager was a senior or mid-level manager was also controlled on performance, dynamic capabilities, and operational capabilities in NPD.

Firm size: The firm’s total number of employees and annual revenues were controlled for their effects on NPD performance.

Industry concentration: Industry concentration is measured as the annual sales revenues for the largest four firms in each 4-digit standard industrial classification code divided by the sales for all firms in the industry.

Industry segment: Industries can be classified as either high tech or low tech industries, following Francis and Schipper’s (1999) classification scheme that is based on the 3-digit SIC industry code. Industry segment case controlled for potential effects on NPD performance.

breakthroughs. Overall environmental turbulence was also measured with two new direct items for validation purposes.

Finally, a number of business unit, firm, and industry variables were controlled for (Table 2).

DATA COLLECTION, ANALYSIS, AND RESULTS

Survey Administration

Two distinct studies were conducted using the same survey instrument and data collection methods. Key informant methodology was employed with NPD
managers as the key respondents (Sethi et al., 2001). This is because NPD managers are typically aware of the major competing NPD units in competitor firms that develop similar products. The survey instrument was first pretested with personal interviews with six academics with focus on NPD, and with 12 NPD managers who offered comments on shaping the measurement items to the NPD context. It was then tested in a small-scale study with 33 NPD managers to examine the statistical properties of the study’s measures. For study I, NPD managers were selected from the 554 participants of the Product Development and Management Association conference (www.pdma.org). For study II, the sample was drawn from the 161 participants of the roundtable management conference (www.CoDev.org). The list was refined by contacting the participants, and inquiring if they had been acting as NPD managers. The final list contained 386 (study I) and 121 (study II) NPD managers. The NPD managers were asked to self-select an NPD business unit that they have been managing. To avoid social desirability bias, they were asked to select a NPD business unit that they are mostly familiar with, and not a typical, successful, or failed one.

To address social desirability bias (Sethi, 2000), the performance of all NPD work units was analyzed. The mean of the success outcomes was 3.44 on a 5-point scale (STD = .78), which was roughly in the middle of the scale. Therefore, social desirability bias is not a serious concern in this study.

Invitation e-mails were sent to the selected respondents, explaining the study’s purpose and assuring that their responses would remain strictly confidential, and all results would only be reported in aggregate. The respondents were asked to click on a link in the e-mail message, which directed them to our online survey instrument (Appendix A). The respondents were offered as incentive a customized report that summarized the results of the study and benchmarked their NPD business unit. Over 90% of the respondents requested this customized report that was sent within a month.

To assure a collective response, the instructions asked the NPD managers to obtain input from other members of their NPD units. Ex-post communication verified that the NPD managers did consult with other unit members. To focus on the NPD unit, the instructions explicitly asked the respondents to focus on their NPD unit’s attributes, not their firm’s attributes. A formal pretest and ex-post communication verified that the respondents focused on their NPD unit’s attributes. Another formal check assessed the respondents’ familiarity with their NPD unit. On a familiarity item, all respondents were deemed familiar (mean = 4.3, STD = .8, minimum = 4.0), and all responses were thus retained. To collect a roughly equal number of intra- and interfirm NPD units, the respondents were asked to favor interfirm NPD units, which helped collect 56% the responses from interfirm NPD units.

Because dyadic data from interfirm NPD work units were desirable, if the participants selected an interfirm NPD unit, they were asked to provide the contact information of the partner’s NPD manager. These NPD managers were then contacted with the same procedure. From the 99 interfirm business units, 47 names were received, and 28 matched pairs were obtained (60% response rate). Dyadic data were separately analyzed for similarities (Jaworski & Kohli, 1993). The average absolute difference for all constructs were less than 5%, the average correlation
between the two NPD managers was .63 (range = .17–.87), and the interrater reliability was .71 ($p < .01$). These results indicate no systematic bias between the two informants, and their responses were averaged to derive a single score for each unit. In study I, 32% were suppliers, 19% customers, and 4% were alliance partners; 45% were internal business units. In study II, 27% were suppliers, 21% were customers, and 10% were alliance partners; 42% were internal business units.

In study I, of the 386 respondents, 44 could not be contacted, 12 respondents indicated that firm policy forbids their participation, and 15 of the invitees indicated that they were not qualified to participate in the study. Following two e-mail reminders, 121 responses were received (39% response rate). In study II, of the 161 participants, 25 were unreachable, and four were unable to respond. Following two e-mail reminders, a total of 59 responses were obtained (43% response rate). The response rate is relatively high because: (i) personal communication was sought with the participants, (ii) the study was endorsed by the conference organizers, (iii) we participated in both conferences and established contacts, and (iv) several completed responses through paper questionnaires were collected during the two conferences. In sum, a total of 180 usable responses were obtained for 180 NPD units from 180 distinct firms.

Nonresponse bias was assessed by verifying that early and late respondents did not differ in their responses. The early respondents were identified by selecting those that responded in the first two weeks. All possible $t$-test comparisons between the means of the two groups in the two empirical studies showed insignificant differences ($p < .1$ level).

Responses were collected from the high-tech (14%), manufacturing (12%), medical devices (11%), consumer goods (8%), and telecom (7%) industries. Less than 5% were collected from the chemical, electronics, auto, and food industries. 80% of the respondents were NPD managers and 10% were NPD executives. The NPD purpose was mostly applied product development (68%), basic research (23%), and routine engineering (9%). Demographics and descriptive statistics were similar between the intra- and interfirm NPD work units. Using Chow’s (1960) test statistic and Wilk’s lambda, the results of both the intra- and interfirm samples were statistically similar. The data from both the intra- and interfirm NPD units were thus pooled together for a single data analysis.

The Measurement Model

Convergent validity, discriminant validity, and unidimensionality were first assessed through an exploratory factor analysis, which showed an ideal loading pattern (Appendix B). The measures were also assessed with LISREL’s confirmatory factor analysis (CFA). The CFA fit indices were: $\chi^2_{741} = 1067$, $\chi^2/df = 1.44$, goodness of fit index (GFI) = .91, adjusted goodness of fit index (AGFI) = .90, normed fit index (NFI) = .95, comparative fit index (CFI) = .97, root mean residual (RMR) = .04. A $\chi^2/df$ ratio below 3 implies a good fit; GFI, AGFI, NFI, and CFI above 0.90 are considered acceptable; RMR below .05 is desirable. Good model fit indices give evidence of convergent validity and unidimensionality. Convergent validity was supported by the large and significant standardized loadings for both the first- and second-order
Table 3: Correlation matrix and composite factor reliability scores for principal constructs.

<table>
<thead>
<tr>
<th>Construct</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dynamic capabilities</td>
<td>.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2. Sensing</td>
<td>.50</td>
<td>.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>3. Learning</td>
<td>.55</td>
<td>.60</td>
<td>.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4. Integrating</td>
<td>.52</td>
<td>.48</td>
<td>.52</td>
<td>.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Coordinating</td>
<td>.47</td>
<td>.45</td>
<td>.50</td>
<td>.61</td>
<td>.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. New product development (NPD) performance</td>
<td>.40</td>
<td>.31</td>
<td>.35</td>
<td>.33</td>
<td>.31</td>
<td>.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Environmental turbulence</td>
<td>.25</td>
<td>.29</td>
<td>.24</td>
<td>.19</td>
<td>.15</td>
<td>-.14</td>
<td>.74</td>
<td></td>
</tr>
<tr>
<td>8. Operational capabilities</td>
<td>.40</td>
<td>.22</td>
<td>.36</td>
<td>.39</td>
<td>.42</td>
<td>.54</td>
<td>-.17</td>
<td>.82</td>
</tr>
</tbody>
</table>

Items on diagonal (in bold) represent reliability scores. Correlations above .15 are significant \( (p < .05) \); above .20 \( (p < .01) \).

constructs \( (p < .001) \), and the \( t \)-values that exceeded the 2.0 threshold. Convergent validity was also supported by calculating the ratio of factor loadings to their respective standard errors, which exceeded \( |2.0| \) \( (p < .01) \). Discriminant validity was tested by showing that the measurement model had a significantly better model fit to a competing model with a single latent construct, and with all other competing models in which pairs of latent constructs were joined. The \( \chi^2 \) difference between the competing models was significantly larger than that of the original model, as also suggested by the factor loadings, modification indices, and residuals (Marsh & Hocevar, 1985). In sum, these tests confirm convergent and discriminant validity and unidimensionality.

Finally, reliability was assessed using both of the composite factor reliability scores. All measures exceeded .70 (Table 3), suggesting adequate reliability. Reliability was also supported because the average variance extracted (Hair, Anderson, Tatham, & Black, 1995) exceeded .70 for all factors. Common method bias was first tested with an exploratory factor analysis in which the study’s 38 measurement items factored in 11 constructs (eigenvalue > 1) that jointly explain 79% of the total variance (Appendix B). Besides, common method bias was also tested with a CFA analysis in which a single-factor model was generated with all 38 measurement items joined into a single latent construct. This model had a poor model fit \( (\chi^2_{741} = 3874, \chi^2/df = 5.23, \text{GFI} = .075, \text{AGFI} = .071, \text{NFI} = .70, \text{CFI} = .77, \text{RMR} = .10) \). These tests did not suggest the presence of common method bias (Podsakoff & Organ, 1986).

The Structural Model

The structural model was tested with LISREL by simultaneously estimating the second-order models along with the structural relationships following Joreskog and Goldberger’s (1975) “multiple indicators and multiple causes” model with both formative and also reflective items (e.g., Diamantopoulos & Winklhofer, 2001). The interaction effects of environmental turbulence were modeled following Ping (1995), centering all variables to avoid identification problems (Cortina, Chen, & Dunlap, 2001). Modeling interaction effects is still a debated issue in the literature;
although Kenny and Judd (1984) suggest the use of all cross products as indicators of latent variables (inflating the degrees of freedom), Ping (1995) proposed a single indicator for a latent variable $X \times Y$ formed by $X$ and $Y$: $X \times Y = \sum X_i \times \sum Y_i$, with the loadings of the interaction variable $X \times Y$ to be: $\lambda_{X,Y} = \sum \lambda_{X_i} \times \sum \lambda_{Y_i}$. Overall, an acceptable model fit was achieved ($\chi^2_{990} = 1,346, \chi^2/df = 1.36, GFI = .93, AGFI = .91, NFI = .97, CFI = .96, RMR = .034$) (Figure 7).

First, as hypothesized, dynamic capabilities have a significant effect on operational capabilities ($b = .36, p < .01$), thus supporting H1.

As expected by the NPD literature, operational capabilities have a strong effect on performance ($b = .41, p < .01$). Given this significant effect, to examine the mediating role of operational capabilities on the performance effects of dynamic capabilities, another model was tested where the path between dynamic capabilities and operational capabilities was omitted, and only a direct path between dynamic capabilities and performance was included. The competing model had inferior fit indices ($\chi^2_{990} = 1,545, \chi^2/df = 1.76, GFI = .88, AGFI = .87, NFI = .92, CFI = .91, RMR = .061$). Because the fit deterioration between the two models was significant ($\Delta \chi^2 = 199, p < .01$), the proposed impact of dynamic capabilities on performance in NPD is shown to be mediated by operational capabilities.

Second, environmental turbulence positively moderated the effect of dynamic capabilities on operational NPD capabilities ($b = .30, p < .01$), thus supporting H2. As expected by the literature (Pavlou & El Sawy, 2006), environmental turbulence had a negative moderating (attenuating) role on the effect of operational capabilities on NPD performance ($b = -.21, p < .01$).

The two moderating effects of environmental turbulence significantly increased the variance explained in the two dependent variables (Carte & Russell, 2003), while a significant model fit deterioration ($p < .01$) was observed when the two moderating effects were omitted from the model. Along with the study’s significant control variables—cross-functional integration, unit size, firm size, high-tech industry—the proposed model explains 63% of the variance in NPD performance.

Dynamic capabilities, operational capabilities, NPD performance, and environmental turbulence were modeled as second-order constructs, and they were...
modeled simultaneously with the rest of the structural model (Figure 7). However, to test the superiority of the second-order models, we compared each of the second-order models to a competing first-order model by calculating the target coefficient index \( T = \chi^2_{\text{first-order model}}/\chi^2_{\text{second-order model}} \) (Marsh & Hocevar, 1985).

For each of the second-order factors, \( T > 0.90 \) (upper bound = 1.0), implying that each of the second-order factors explains almost all of the covariance in the corresponding first-order factor, implying that each of the second-order factors is adequate (despite being more parsimonious). We also modeled a reflective second-order model for each of the four constructs, which resulted in significantly poorer model fit indices, suggesting a considerable fit deterioration, thus rendering a reflective model less likely. In sum, these tests validate the proposed second-order formative models. These findings suggest that the proposed LISREL model with the second-order factors is a superior representation.

**IMPLICATIONS FOR DECISION-MAKING THEORY AND PRACTICE**

This study has two key findings. First, it identifies and articulates a set of dynamic capabilities (Figure 1), and it proposes a measurable model to represent the nature of dynamic capabilities. Second, it empirically supports a structural model in which dynamic capabilities have an indirect positive effect on performance by reconfiguring operational capabilities in NPD, an effect that is positively moderated (reinforced) by environmental turbulence (Figure 2). These two key findings have implications for (i) conceptualizing, operationalizing, and measuring dynamic capabilities, and (ii) understanding the effects of dynamic capabilities in turbulent environments.

**Implications for Conceptualizing, Operationalizing, and Measuring Dynamic Capabilities**

Dynamic capabilities have been viewed as hidden and intangible assets, an elusive black box. Winter (2003) notably explains: “probably some of the mystery and confusion surrounding the concept of dynamic capability arises from linking the concept too tightly to notions of generalized effectiveness at dealing with change and generic formulas for sustainable competitive advantage. The argument here is that clarity is served by breaking this link” (p. 994). Such confusion has made it difficult for managers to understand, measure, and thus act upon dynamic capabilities. Dynamic capabilities have also been criticized for a lack of empirical grounding and measurement (Williamson, 1999), and attempts to measure dynamic capabilities have merely used distant proxies (e.g., Henderson & Cockburn, 1994; Nerkar & Roberts, 2004; Arend & Bromiley, 2009). Integrating the dynamic capabilities, decision sciences, and NPD literatures, this study clarifies the semantics of dynamic capabilities, sheds light on their inner-workings, and offers a simple model to conceptualize, operationalize, and measure dynamic capabilities. Although Teece (2007) developed a comprehensive framework to capture numerous activities in the realm of dynamic capabilities, this study offers a parsimonious
The Elusive Black Box of Dynamic Capabilities

model with a limited set of specific, concrete, and measurable dynamic capabilities. The study also identifies the underlying components of each capability, thus showing that the proposed capabilities closely correspond to the dynamic capabilities literature. Our measurable model alleviates the criticism that dynamic capabilities cannot be measured, and they are thus born, not made (Winter, 2003, p. 991), and it has implications for offering an actionable set of dynamic capabilities that decision-makers can use to manage in turbulence.

Viewing dynamic capabilities as abstract capabilities has created a “doubt that deliberate efforts to strengthen dynamic capabilities are a genuine option for managers” (Winter, 2003, p. 991). The proposed model of dynamic capabilities with specific actionable guidelines for managers suggests that dynamic capabilities are managerially-amenable practices that managers can readily act upon. Teece et al. (1997, p. 521) argue: “the capacity to reconfigure and transform is itself a learned organizational skill. The more frequently practiced, the easier accomplished.” This study helps managers understand what dynamic capabilities are, how they can be measured, thus offering guidance to identify, measure, benchmark, and enhance dynamic capabilities to enhance decisions in turbulent environments. The proposed model also creates a common language between managers and researchers to allow further empirical research on dynamic capabilities.

Besides dynamic capabilities, agility is another means proposed in the literature to manage in turbulent environments (Sambamurthy et al., 2003). Although agility stresses the ability to sense and respond, the proposed model of dynamic capabilities offers a more complete picture of how managers can address turbulent environments. Having sensed the opportunities in the environment, the “respond” component of agility is captured with the ability to learn to revamp existing operational capabilities with new knowledge, integrate the new knowledge in the reconfigured operational capabilities, and coordinate to synchronize tasks, resources, and activities to deploy the reconfigured operational capabilities. The proposed model of dynamic capabilities outlines the exact factors needed to respond to opportunities by reconfiguring existing operational capabilities. It thus offers more specific and actionable guidelines for manages to decide and act in turbulence.

Although dynamic capabilities have been viewed as firm-level capabilities relevant only to decision-makers at the top executive level, this study shows that dynamic capabilities are also relevant for lower-level managers that make decisions about intra- or interfirm business units. This has implications for the dynamic capabilities view by extending the level of analysis beyond the overall firm level to the business unit as the level of analysis. This also has implications for the enhanced scope of dynamic capabilities for virtually all levels of decision making throughout the firm and extending the scope of dynamic capabilities to business unit managers.

Implications for Understanding the Effects of Dynamic Capabilities

Although the literature intuitively agrees that dynamic capabilities are valuable assets, this study empirically validates this intuition. Also, by describing the process by which dynamic capabilities impact performance by reconfiguring operational
capabilities, this study empirically overcomes Williamson’s (1999) tautological criticism of the dynamic capabilities view. This implies that dynamic capabilities do have an effect on performance, but they do so indirectly by reconfiguring operational capabilities into new ones that better fit the environment. The proposed “indirect” view extends Zott’s (2003) direct, straightforward link between dynamic capabilities and performance.

By implying that dynamic capabilities are only valuable in turbulent environments, the literature has assumed that dynamic capabilities are worthless or even harmful in more stable environments (Moorman & Miner, 1998). To overcome this apparent misconception, this study shows the positive role of dynamic capabilities in the entire spectrum of environmental turbulence. Although we cannot confirm that this study’s levels of environmental turbulence represents perfectly stable environments, this finding may be explained by the fact that dynamic capabilities can earn even higher rents by effectively reconfiguring existing operational capabilities. Penrose (1959) viewed resources as pieces of a “jigsaw puzzle” (p. 70) that can be destroyed and recombined to produce superior outputs given new opportunities. This finding implies that dynamic capabilities are valuable in virtually all levels of environmental turbulence, implying that managers must continuously try to identify new opportunities and make decisions to reconfigure their existing operational capabilities, irrespective of the level of environmental turbulence.

Limitations and Suggestions for Future Research

First, assuming that dynamic capabilities correspond to the exploration and operational capabilities to the exploitation mode (March, 1991), firms face a trade-off between focusing on dynamic versus operational capabilities. Although an emphasis on dynamic capabilities may create disruptions to the efficiency of existing operational capabilities, a focus on operational capabilities may eventually result in rigidities. Given the ability to directly measure dynamic capabilities with our proposed measurable model, future research could identify an optimum solution given the degree of environmental turbulence. This might help achieve the ambidextrous organization that optimizes the trade-off between dynamic capabilities and operational capabilities.

Second, the measurable model of dynamic capabilities opens avenues for empirical research. Having identified a measurable model of dynamic capabilities, it is possible to examine how dynamic capabilities can be enhanced by identifying their antecedents. Because dynamic capabilities are information-intensive, IT may help facilitate dynamic capabilities (e.g., Ettlie & Pavlou, 2006; Pavlou & El Sawy, 2006). This may help address the question how IT influences competitive advantage in turbulent environments (Sambamurthy et al., 2003). Also, recent work proposed various antecedents of dynamic capabilities at the individual, firm, and network level (Rothaermel & Hess, 2007). It is also possible to integrate dynamic capabilities with related reconfiguration capabilities. For instance, Winter (2003) presents a trade-off between dynamic capabilities and improvisation. Future research could examine the impact of dynamic capabilities and improvisation on performance in different levels of environmental turbulence.
Third, the study’s unit of analysis (business unit) implies that dynamic capabilities can be uniform across the firm, and they may differ in terms of the business unit’s operational capabilities they seek to reconfigure. For example, firms may be more effective in reconfiguring their operational capabilities in NPD versus in manufacturing or in logistics. Some firms may have different emphasis in reconfiguring different types of operational capabilities, or they may have a different approach for dealing with environmental turbulence for shaping operational capabilities in different business units. Future research could extend the study of dynamic capabilities to specific business units, areas, and functions in the firm beyond this study’s NPD context.

Fourth, despite our focus on NPD, because dynamic capabilities do not contain a “certain domain of knowledge or skill, but the ability to learn new domains” (Danneels, 2002, p. 1112), we have no reason to believe that our model will not generalize to other levels and units of analysis. However, the study’s generalization to other contexts, levels, and units of analysis remains to be examined.

Finally, we hope that the proposed simple and measurable model of dynamic capabilities is a helpful stepping stone that will allow researchers to do further research by better conceptualizing, operationalizing, and measuring dynamic capabilities, and that it will also help give managers more specific and actionable guidelines to make high-quality decisions in turbulent environments. [Received: October 2008. Accepted: May 2010.]

REFERENCES


**APPENDIX A: MEASUREMENT ITEMS**

**Dynamic capabilities**

*Instructions:* “Please rate the effectiveness by which your work unit reconfigures its operational capabilities in the NPD process to address rapidly-changing environments relative to your major competitors.”

**Sensing capability**
We frequently scan the environment to identify new business opportunities.
We periodically review the likely effect of changes in our business environment on customers.
We often review our product development efforts to ensure they are in line with what the customers want.
We devote a lot of time implementing ideas for new products and improving our existing products.

**Learning capability**
We have effective routines to identify, value, and import new information and knowledge.
We have adequate routines to assimilate new information and knowledge.
We are effective in transforming existing information into new knowledge.
We are effective in utilizing knowledge into new products.
We are effective in developing new knowledge that has the potential to influence product development.

**Integrating capability**
We are forthcoming in contributing our individual input to the group.
We have a global understanding of each other’s tasks and responsibilities.
We are fully aware who in the group has specialized skills and knowledge relevant to our work.
We carefully interrelate our actions to each other to meet changing conditions.
Group members manage to successfully interconnect their activities.

**Coordinating capability**
We ensure that the output of our work is synchronized with the work of others.
We ensure an appropriate allocation of resources (e.g., information, time, reports) within our group.
Group members are assigned to tasks commensurate with their task-relevant knowledge and skills.
We ensure that there is compatibility between group members expertise and work processes.
Overall, our group is well coordinated.
Reconfiguration capability (indicator items for second-order constructs)
We can successfully reconfigure our resources to come up with new productive assets. We often engage in resource recombinations to better match our product-market areas and our assets.

NPD performance
Please rate the performance of your NPD work unit relative to your major competitors in the following aspects:

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<tbody>
<tr>
<td>Overall development costs</td>
<td>Improvements in product quality and functionality</td>
<td>We have gained strategic advantages in the marketplace over our competitors</td>
</tr>
<tr>
<td>Overall efficiencies of NPD process</td>
<td>Major innovations in products as a whole</td>
<td>We have gained a competitive advantage</td>
</tr>
<tr>
<td>Accelerated time-to-market</td>
<td>Creation of new product concepts</td>
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Operational capabilities in NPD
3a. Technical capability
Evaluating the technical feasibility of developing new products with continuously changing features. Recurrently evaluating tests to determine basic performance against shifting technical specifications. Frequently executing prototypes or sample product testing.

3b. Customer capability
Frequently determining market characteristics and trends. Regularly appraising competitors and their products—both existing and potential. Executing several test-marketing programs in line with commercialization plans.

3c. Managerial capability
Management effectively monitors the progress of this NPD group. Management is actively involved in activities at the working level. Management effectively administers relevant tasks and functions.

Overall NPD capability (indicator items)
We do a remarkable job of developing new products. Our product development group gives us an edge in the market.

Environmental turbulence
The technology in this product area is changing rapidly. Technological breakthroughs provide big opportunities in this product area. In our kind of business, customers’ product preferences change a lot over time. Marketing practices in our product area are constantly changing. New product introductions are very frequent in this market. The environment in our product area is continuously changing. Environmental changes in our industry are very difficult to forecast.
Control variables

Cross-functional integration
There are frequent interactions between our cross-functional NPD group. The NPD process is truly a cross functional effort.

Group NPD experience
How long has this NPD group been in place? _________ years.

NPD innovation type [Select one option]
Basic research that lays the basic foundations for future product development effort.
Applied work to develop specific, clearly defined products to fulfill immediate goals and strategic directions. [Applied NPD]
Routine engineering for continuous improvement of existing products and processes. [Routine engineering]

Intra- Vs. interorganizational NPD business units
Our NPD partner is a (please circle one): (a) supplier, (b) customer, (c) internal unit, (d) other (please specify): _____

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Continued
## APPENDIX B: (Continued)

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Paul A. Pavlou is an associate professor of management information systems, marketing, and management and a Stauffer senior research fellow at the Fox School of Business at Temple University. He received his PhD from the University of Southern California in 2004. His research focuses on e-commerce, online auctions, IT strategy, information economics, research methods, and NeuroIS. His research has appeared in MISQ, ISR, JMIS, JAIS, JAMS, and CACM, among others. His work has been cited over 1,100 times by the Social Science Citation Index of the Institute of Scientific Information and over 3,000 times by Google Scholar. He won several best paper awards for his research, including the “ISR Best Paper” award in 2007, the 2006 “IS Publication of the Year” award, the “Top 5 Papers” award in Decision Sciences in 2006, among others. He also won several Reviewer awards, including the 2009 Management Science Meritorious service award, the “Best Reviewer” award of the 2005 Academy of Management Conference, and the 2003 MIS Quarterly “Reviewer of the Year” award.

Omar A. El Sawy is a professor of information systems at the Marshall School of Business at the University of Southern California (USC). His interests are around IT-enabled business strategy in turbulent environments and designing business models for services offered through digital platforms. He served as Director of Research for USC’s Institute for Communication Technologies Management from 2001 to 2007, where he led industry-sponsored research programs. He holds a PhD from Stanford Business School, an MBA from the American University in Cairo, and a BSEE from Cairo University. El Sawy is the author or coauthor of over 100 papers, serves on several journal editorial boards, and is a six-time winner of the Society for Information Management’s Paper Awards Competition. One of his previous papers in Information Systems Research with Paul Pavlou won the 2007 best published paper award. He is a Fellow of the Association of Information Systems.