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May 15, 2012

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May 2012
Working Paper

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Abstract

Firm-level product innovation theory today is ambiguous, conflated, fragmented, incomplete, unbalanced and inconsistent. This paper addresses these shortcomings and distinguishes between the overall process of product innovation (new product development) and its outputs of new-to-the firm, internally-sourced product invention, externally-sourced product adoption, and product commercialization. Because product innovation theory involves multiple domains (decision-making, processes and outputs), a multitheoretical approach is taken that employs four theoretical building blocks of related theories that explain firm-level product innovation: evolution (evolution, path-creation, path-dependence theories), intelligence (organizational learning, rational search, knowledge management theories), decision-making (limited rationality, contingency, real options theories) and resources/capabilities (resource-based view, dynamic capabilities theories). This paper formulates a firm-level conceptual framework where strategic decision-making and resources develop absorptive capacity needed for product invention/adoption. Firm product invention/adoption, together with its developed absorptive capacity and complementary assets, achieve product commercialization necessary for firm success.

In Saxe's (1873) "The Blind Men and the Elephant," six blind men meet an elephant, each feeling a different part: the first bumps into a side and declares that it is a wall; the second touches a tusk and proclaims that it is a spear; the third handles the trunk and asserts that it is a snake; the fourth pats a knee and contends that it is a tree; the fifth rubs an ear and avows that it is a fan; and the sixth strokes the tail and states that it is a rope. Saxe (1873, p. 136) concludes:

> And so these men of Indostan
> Disputed loud and long,
> Each in his own opinion
> Exceeding stiff and strong,
> Though each was partly in the right,
> And all were in the wrong!

While an amusing children's story, this poem serves as an apt analogy of the state of product innovation (PI) theory today, with scholars viewing PI in many different ways. (Note that PI is just one of Schumpeter's (1934) five types of innovation: product, process, sourcing, market and organization. The other four innovation types are not examined in this paper.) PI theory today is *ambiguous, conflated, fragmented, incomplete, unbalanced* and *inconsistent*.

PI theory is *ambiguous*, such that even the meaning of "innovation" is debated (Adams, Bessant & Phelps, 2006; Crossan & Apaydin, 2010; Tidd, 2001). PI theory is *conflated* because scholars often blur PI's two distinct outcomes, technological invention and commercial innovation (Fleming, 2001), and frequently treat those two outcomes as processes as well (Arthur, 2007; Crossan & Apaydin, 2010).

PI theory is also *conflated* because it fails to distinguish between the PI roles of exploration and exploitation that March (1991) identifies as different forms of organizational learning (Crossan & Apaydin, 2010). Exploitation is the "refinement of an existing technology" and "refinement and implementation of what is known" while exploration is the "invention of a new one" (technology) and "pursuit of what might come to be known" (March, 1991, p. 72,

2006, p. 205). Critical learning that takes place within the PI process is often conflated with PI outcomes (Li, Vanhaverbeke & Schoenmakers, 2008), as some scholars treat exploration and exploitation processes as outcomes, often linking them respectively to radical and incremental innovations (e.g., Greve, 2007; He & Wong, 2004; Jansen, Van den Bosch & Volberda, 2006).

PI theory is further *conflated* because learning from experience is often blurred with learning from knowledge search (Gupta, Smith & Shalley, 2006). March (1991) links knowledge search and discovery with exploration, and connects experiential learning from refinement and implementation with exploitation. While some scholars consider exploration as including all forms of knowledge search (e.g., Baker & Sinkula, 2007; Rosenkopf & Nerkar, 2001), others treat exploitation as local knowledge search and exploration as distant knowledge search (e.g., Benner & Tushman, 2002; Sidhu, Commandeur & Volberda, 2007). By treating experiential learning as local knowledge search, the latter group of scholars ignore the strong influence of experience, "learning by doing" (Argote, Beckman & Epple, 1990, p. 141) that favors more certain returns from exploitation over less certain returns from exploration (March, 1991).

PI theory is *fragmented* because it misses causal relationships between PI decision-making, processes and outcomes (Crossan & Apaydin, 2010; Kessler, 2004; Wolfe, 1994). The theoretical disconnection between PI decision-making and processes ignores how firm senior management's intentions and decisions influence PI processes (Kessler, 2004). PI theory is *incomplete* because it often does not account for both internal (product invention) and external (product adoption) PI sources (Crossan & Apaydin, 2010). PI theory is *unbalanced* because it has emphasized outcomes over process (Crossan & Apaydin, 2010). Last, PI theory is *inconsistent* because empirical PI studies have employed inconsistent operationalization of their primary constructs, yielding mixed results (Crossan & Apaydin, 2010; Harmancioglu Droge & Calantone, 2009).

Hence, PI scholarship has created ambiguous theoretical constructs, varying construct operationalization, and mixed empirical results, thereby impeding theory-building.

Given the importance of PI to firm success (Brown & Eisenhardt, 1995; Roberts, 1999), the lack of a theoretical framework for firm-level PI is troubling. However, the raw materials for PI theory-building are abundant within extant scholarship. This paper builds PI theory by first identifying PI as a dynamic capability, the overall process of producing new-to-the firm outcomes of product invention/adoption and product commercialization. Then, four theoretical building blocks (evolution, intelligence, decision-making, and resources/capabilities) are deployed to support theory development in the three PI domains of decision-making, processes and outcomes. Further, the firm's PI decision-making framework is articulated using limited rationality, real options, and two overarching, contingent factors of strategic uncertainty and capability development. Stemming from this PI decision-making framework, four PI decisions of product variation, selection, replication and retention initiate four corresponding PI process phases that reduce the firm's strategic uncertainty and increase its capability development via organizational learning, rational search and knowledge management. Two PI process phases, selection and retention, respectively produce three key outputs of product invention/adoption and product commercialization that are explained by resource-based view and dynamic capabilities.

The integrated PI theory in this paper is *unambiguous*, *distinct*, *unified*, *complete*, *balanced* and *consistent*. (See Table 1 for an overview of this paper's integrated PI theory.) It is *unambiguous* because in this paper's PI theory "innovation" is a term associated only with the overall new product development process and not with the outputs of product invention/adoption and product commercialization. This paper's developed PI theory is *distinct* because it clearly delineates between the outcomes of product invention/adoption and product commercialization,

separate from the learning processes of exploration and exploitation that are respectively linked to learning from knowledge search and learning from experience. It is *unified* because it links the three PI domains of decision-making, processes and outputs through causal relationships. This paper's developed PI theory is *complete* because it incorporates both internal innovation sources (product inventions) and external innovation sources (product adoptions). It is *balanced* because PI decision-making, processes and outcomes are treated equally. Finally, this paper's developed PI theory is *consistent* because it allows for stable operationalization of its primary constructs that can lead to more reliable empirical results. This paper's PI theory development represents the first step in constructing an integrated theoretical framework that explains firm product innovation.

Insert Table 1 about here

PRODUCT INNOVATION AND ITS OUTPUTS

The scope of this paper is the firm's overall PI process. The PI process is a dynamic capability of the firm that is initiated and directed by PI decision-making, enacted by PI processes and fulfilled through PI outputs (Crossan &Apaydin, 2010; Eisenhardt & Martin, 2000). Synthesizing the PI literature, *product innovation is the firm's dynamic capability to transform ideas into products that create value for the firm, achieved by the firm's decisions and processes to select new-to-the-firm product concepts in the form of either internally-sourced product inventions or externally-sourced product adoptions, product inventions/adoptions that are further developed by the firm to appropriate value through product commercialization in target product markets* (Adams et al., 2006; Daft, 1978; Damanpour & Schneider, 2006; Eisenhardt & Martin, 2000; Fleming, 2001; Mizik & Jacobson, 2003).

To better understand the product innovation definition above, five of its terms require clarification: dynamic capability, new-to-the-firm product concepts, product invention, product adoption, and product commercialization. *A dynamic capability is a firm process that develops, integrates and reconfigures firm resources and capabilities to achieve new forms of competitive advantage* (Eisenhardt & Martin, 2000; Teece, Pisano & Shuen, 1997). The key terms in this definition are "resources" and "capabilities". Penrose (1959, pp. 65, 76) describes a resource as a "bundle of possible services" and notes that a firm has "pools of unused productive services" that result from the learning/knowledge interaction of its human and material resources. Winter (2000, p. 983) defines capability as "a high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type," noting that a capability has value only in relation to a specific competitive context at a particular point in time. Teece et al. (1997, p. 515) assert that the term "dynamic" in "dynamic capabilities" refers to the firm's ability to renew its capabilities to adapt to its changing environment.

New-to-the-firm product concepts are resource configurations that are novel from the firm's perspective, not necessarily new-to-the industry or new-to-the-world from an outside observer's perspective (Ahuja & Lampert, 2001; Daft, 1978; Gupta, Teslak & Taylor, 2007). While the novelty degree here is at the lowest of three possible value creation levels, "new-to-the-firm" product concepts require that the firm explores new knowledge and develops new capabilities that are the essence of the product innovation overall process (Damanpour, 1996; Greve, 2007; March & Simon, 1958). In the literature, there are PI output types of various degrees of novelty and value, e.g., radical versus incremental, competence-enhancing versus competence-destroying, architectural versus generational, core versus peripheral (Gatignon,

Tushman, Smith & Anderson, 2002); however, these diverse PI output types lack clear distinction due to different levels of analysis and theoretical perspectives (Harmancioglu et al., 2009). Thus, this paper's theoretical framework focuses only on product innovation that is new to the firm and ignores product improvements that are often termed "incremental" innovations.

The three PI outputs are product invention, product adoption, and product commercialization. While product invention/adoption and its commercialization are distinct outputs (Schumpeter, 1927), internally-sourced product inventions and externally-sourced product adoptions precede their commercialization (Brozen, 1951; Solo, 1951). *Product inventions are selected product concept alternatives, concepts internally developed by the firm through external knowledge search or internal experiential learning, that are new-to-the-firm combinations of technologies (purpose, practices and components) or recombinations of prior combined technologies, which serve purposes valued by others such as solving problems or exploiting opportunities* (Arthur, 2007; Daft, 1978; Fleming, 2001; Kogut & Zander, 1992). *Product adoptions are selected product concept alternatives, concepts externally acquired by the firm via imitation, vicarious learning or other acquisitive means, that are new-to-the-firm combinations of technologies (purpose, practices and components) or recombinations of previously combined technologies, which serve purposes valued by others such as solving problems or exploiting opportunities* (Daft, 1978; Damanpour & Schneider, 2006; Kogut & Zander, 1992; Terlaak & Gong, 2008). Hence, product inventions/adoptions are key sources of firm value creation. *Product commercializations are effective introductions by the firm of its developed product inventions/adoptions into target product markets for the purposes of achieving competitive advantages in those markets and earning satisfactory rents for its efforts* (Adams et al., 2006; Eisenhardt & Martin, 2000; Teece et al., 1997; Zaltman, Duncan, & Holbek, 1973). Thus,

product commercialization fulfills the aim of the firm's overall PI process: to appropriate value for the firm. The three PI outputs (see Table 1) are produced by key activities that operate sequentially and recursively within the overall PI process. These activities result from the firm's prime intention to create and appropriate value, an intention manifested in a series of PI decisions made by the firm. PI decision-making, processes and outcomes are interrelated, multifaceted phenomena requiring a multitheoretical approach to explain them.

A MULTITHEORETICAL APPROACH

PI literature today infrequently employs theory and, when it does, the theories applied are diverse (Crossan &Apaydin, 2010). At the organizational level of analysis, PI has been explained by a variety of theories: contingency (e.g., Tidd, 2001), dynamic capabilities (e.g., Eisenhardt & Martin, 2000), evolutionary economics (e.g., Nelson & Winter, 1982), knowledge management (e.g., Cohen & Levinthal, 1990), organizational learning (e.g., Van de Ven & Polley, 1992), real options (e.g., McGrath, 1997) and resource-based view (e.g., Danneels, 2002), with knowledge management and organizational learning theories most frequently employed within the PI literature (Crossan & Apaydin, 2010).

Scholars advocate a multitheoretical approach to better explain PI's diverse phenomena (Crossan & Apaydin, 2010; Wolfe, 1994). Reviewing the literature, some basic characteristics of PI are that it is: (1) evolutionary, guided by various learning mechanisms that cope with environmental uncertainty (Eisenhardt & Martin, 2000; Tidd, 2001); (2) a dynamic system consisting of cycles of divergent and convergent activities, e.g., "recursive problem solving" (Arthur, 2007, p. 275; Crossan & Apaydin, 2010); (3) enabled by learning-inspired decision-making that makes deliberate resource allocations (Winter, 2000); (4) a dynamic capability that can change the firm's resource configuration and develop its capabilities over time (Danneels,

2002), in either path-dependent or path-creation fashion (Garud, Kumaraswamy & Karnøe, 2010; Sydow, Schreyögg & Koch, 2009; Vergne & Durand, 2010); and (5) fulfilled by products that create and appropriate value (Bowman & Ambrosini, 2000; Mizik & Jacobson, 2003). A multitheoretical approach can be viewed as laying a stack of theoretical building blocks that progressively support each other. (See Table 2.)

Insert Table 2 about here

Evolution

Evolution, the fundamental theoretical building block, is both a process and outcome of history: evolution as a process embodies the temporal mechanisms that efficiently and inefficiently generate historical paths; evolution as an outcome represents ordered change, historical sequences that are not arbitrary (March, 1994). In the context of organizational PI, theories of evolution (see Table 2, Box T-1) include evolution (Campbell, 1965), coevolution (Lewin & Volberda, 1999), path creation (Garud et al., 2010) and path dependence (Vergne & Durand, 2010). Evolutionary processes comprise: (1) variation, the generation of new product invention/adoption alternatives, emerges from blind or random changes, or from deliberate efforts constrained by time and other resources; (2) selection, the choice among product invention/adoption alternatives for those with the greatest value, results either from competition for scarce resources or vicariously using prior knowledge and anticipating competitive environment selection; and (3) retention, the preservation and reproduction of previously selected product inventions/adoptions to capture maximum value, results in consistency over time and across units, and involves forces promoting selected initiatives for future use, such as formalization or codification of routines that seem to be effective, e.g., product commercialization (Aldrich, 1999; Amburgey, Dacin & Kelly,

1994; Baum, 1999; Campbell, 1965; Volberda & Lewin, 2003). Zollo and Winter (2002) extend the three-stage evolutionary variation-selection-retention (VSR) model to a four-stage VSRR model by advocating a knowledge evolution cycle that includes replication as a step between selection and retention (see Box P-1). Winter and Szulanski (2001) note that replication applies product inventions/adoptions and their associated routines in diverse contexts to experientially generate new information requiring significant cognitive efforts to analyze, often causing product inventions/adoptions and routines to be modified or new ones created. They conclude that experiential learning gained from exploiting in different contexts is the essence of replication. An extension of evolutionary theory is coevolution, mutual adaptation/development that occurs both ways across levels of analysis, e.g., firm functions, the firm, and the firm's external environment, such that firm characteristics, e.g., PI process, are influenced by, and influence, features of lower and higher levels of analysis (Aldrich, 1999; Koza & Lewin, 1998; Lewin & Volberda, 1999; Murmann, Aldrich, Levinthal & Winter, 2003; Van de Ven & Garud, 1994; Volberda & Lewin, 2003). Besides being multilevel and multidirectional in causality, coevolution features embedded VSR processes, nonlinearity, positive feedback, and path dependence (Lewin & Volberda, 1999). Path creation theory explains how actors break out from their pasts via exploration to create new initiatives for the future, e.g., innovations (Garud et al., 2010; Sydow et al., 2009). Path dependence, viewed in the literature as both a process and an outcome, promotes persistence and escalation of commitment (see Box D-1), allows recombination of past knowledge and other resources, and may lead to technological "lock-in" (see Box P-1; Burgelman, 2002; Kogut & Zander, 1992; Leonard-Burton, 1992; Sydow et al., 2009; Vergne & Durand, 2010). PI generates path dependencies as it develops organizational capabilities that determine which new products the firm is likely to develop and be successful at (Danneels, 2002; Vergne & Durand, 2010).

The evolution theoretical building block supports the intelligence, decision-making, and resources/capabilities theoretical building blocks. In terms of intelligence (see Box T-2), evolution theories explicitly sustain theories of organizational learning (March, 1991), rational search (March & Simon, 1958), and knowledge management (Zollo & Winter, 2002), as experiential learning requires past experience (Levinthal & March, 1993) while knowledge from learning accumulates over time (Argote et al., 1990; Nonaka, 1994). More specifically, variation promotes organizational learning and knowledge creation through experimentation (Madsen, Mosakowski & Zaheer, 1999). In terms of decision-making (see Box T-3), key tenets of evolution theories are assumed in: limited rationality theory (Cyert & March, 1963; March & Simon, 1958) because aspirations are derived in part from historical performance (Audia & Greve, 2006); contingency theory (Kessler, 2004) because PI decision-making is based on the firm's past experience with various technologies and markets (Burgelman, 1991), including its product history that constrains the firm's options for future product sequences (Helfat & Raubitschek, 2000); and real options theory because as uncertainty is reduced over time, the value of previously created real options is increased (McGrath, 1997). In terms of resources/capabilities (see Box T-4), theories of evolution are implicit in resource-based view (RBV; Barney 1991) and dynamic capabilities theories (Teece et al., 1997) because both theories assume that capabilities evolve over time due to changes in competitive standards and learning responses to those changes (Helfat, 2000; Winter, 2000).

Intelligence

"Organizations pursue intelligence" (March, 2006: 201). The intelligence theoretical building block (see Table 2, Box T-2) reflects the firm's efforts to reduce its external and internal environments' technological and market uncertainty associated with product innovation (Adams

et al., 2006; Tidd, 2001). The firm tries, sometimes imperfectly, to reduce this uncertainty through rational knowledge search (Levinthal & March, 1993; March, 1991; Rosenkopf & Nerkar, 2001) and experiential and vicarious learning (Corbett, 2005; Srinivasan, Haunschild & Grewal, 2007; Terlaak & Gong, 2008; Van de Ven & Polley, 1992). The organization learns through the feedback of outcomes produced by its actions (Dornblaser, Lin & Van de Ven, 1989). Supported by the evolution theoretical building block, intelligence needed for innovation is explained using organizational learning, rational search and knowledge management theories.

Organization learning theory (Crossan, Lane & White, 1999) produces the learning process constructs of exploration and exploitation (see Boxes D-2 and P-2) that are intimately involved in PI processes (March, 1991). PI serves as an instrument of organizational learning and contributes to organizational renewal (Danneels, 2002). Just like PI, scholars today view organizational learning as both a process and an outcome, but focus more attention on the outcome rather than the process (Crossan, Maurer & White, 2011). Organizational learning processes (see Box P-2) are involved in capability learning (Winter, 2000), and guide the evolution of dynamic capabilities (Eisenhardt & Martin, 2000). Organizational learning precedes knowledge management, as learning is knowledge acquisition (Argote et al., 1990). Organizational learning theory concentrates on processes by which knowledge changes or flows, while knowledge management theory emphasizes knowledge as an asset or stock (Dierickx & Cool, 1989; Spender, 1994). These two theories have yet to be integrated (Crossan et al., 2011). Since this paper focuses at the organizational level of analysis, interorganizational learning theory (Lane & Lubatkin, 1998) is not addressed.

Rational search theory assumes that there are various investment opportunities with probability distributions of investment returns that are initially unknown (see Box D-2; March,

1991). March and others view knowledge search and discovery as exploration while regarding experiential learning as exploitation (Baker & Sinkula, 2007; Gavetti & Levinthal, 2000; Levinthal & March, 1993; March, 1991; Rosenkopf & Nerkar, 2001).

Knowledge management theory (Nonaka, 1994) supports a key component of RBV theory known as the knowledge-based view (Grant, 1996) that is implicitly involved in PI decision-making (Kessler, 2004; Zollo & Winter, 2002), processes (Eisenhardt & Martin, 2000), and outcomes (see Box O-2): (1) intermediate PI outcomes include absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2002), complementary assets (Teece, 1986), patents (Levitas & McFadyen, 2009), and product inventions (Arthur, 2007); and (2) final PI outcomes include the knowledge component of commercialized products (Danneels, 2002) and organizational memory—knowledge stored (sometimes forgotten) in individuals, cultures, routines, structures, and workplaces (Casey & Olivera, 2011; Easterby-Smith & Lyles, 2011; Walsh & Ungson, 1991).

The intelligence theoretical building block supports the decision-making and resources/-capabilities building blocks. In terms of decision-making, key tenets of learning/search/knowledge theories are assumed by the following PI decision-making theories (see Box T-3): limited rationality theory relies on rational search theory as well as learning implicit in performance feedback that employs performance-aspiration gaps (Cyert & March, 1963; Greve & Taylor, 2000); contingency theory, specifically nonprogrammed decision-making, relies on intuition which is based on experiential learning (Kessler, 2004); and real options theory views investment in R&D that gains new knowledge as a real option (McGrath & Nerkar, 2004). In terms of resources/capabilities (see Box T-4), learning/search/knowledge theories are implicit in both RBV and dynamic capabilities theories because initial organizational knowledge, search processes and managerial learning are required in developing firm capabilities (Winter, 2000).

Decision-Making

Supported by the evolution and intelligence building blocks, the decision-making theoretical building block reflects that PI decision-making is explained by limited rationality, contingency and real options theories (see Table 2, Boxes T-3 and D-3). Limited rationality theory views PI decision-making as based on comparisons made of target aspiration levels with performance levels in light of slack and other resource constraints (Cyert & March, 1963; March, 2008; March & Simon, 1958; Simon, 1955). Limited rationality theory assumes that search is constrained (exploitation) if the most preferred alternative is above but near target aspiration levels that are socially constructed and historically derived, and that search is stimulated (exploration) if the most preferred alternative is below target aspiration levels (Audia & Greve, 2006; Greve, 2002; Greve & Taylor, 2000; March, 1991; March & Simon, 1958). Target aspiration levels stem from firm strategies that, in turn, are generated in deliberate, induced (top-down) and emergent, autonomous (bottom-up) fashions (Burgelman, 1983; Mintzberg & Waters, 1985). Limited rationality theory incorporates management intentionality and sees PI as organizational change, aligned with Crossan et al.'s (2011) view that institutionalizing learning requires changing existing organizational routines.

Contingency theory (Lawrence & Lorsch, 1967) reflects environmental-dependent PI decision-making (see Box P-3; Damanpour 1996) regarding the firm's initiation (performance/opportunity gaps identified; knowledge search conducted; product concept alternatives generated), selection (product concept alternatives evaluated and best chosen; product concept's development supported), and implementation (commercialization) innovation processes (Kessler 2004). PI decisions are nonprogrammed choices required in the face of new and complex phenomena, requiring judgment based on intuition and creativity because these decisions often fall outside

organizational decision rules (Kessler 2004). PI decisions are two kinds (see Box D-3): (1) pro-active design decisions that enable the overall PI process and configure firm PI-related resources and capabilities; and (2) reactive behavioral decisions that deal with individual, group and organizational perspectives regarding product concept evaluations and choices, and communicate implementation of product decisions to obtain organizational acceptance (Kessler 2004).

Real options theory addresses PI investment decision-making under innovation uncertainty (Bowman & Hurry, 1993; McGrath, 1997; McGrath & Nerkar, 2004). "Real options reasoning" is the rationale used by decision-makers regarding the value of generating future decision rights, i.e., real options, in their PI investments (McGrath & Nerkar, 2004, p. 1). Real options theory explains PI decision-making (see Box D-3) in the face of knowledge asymmetries that develop from the experiential and path-dependent nature of the overall PI process (Dierickx & Cool, 1989; McGrath, 1997). Hence, real options are employed by firms to reduce their innovation uncertainty and make PI decision-making less risky, such that an R&D investment decision is a decision to invest in real options (McGrath & Nerkar, 2004).

The decision-making theoretical building block supports the resources/capabilities building block (see Box T-4). Limited rationality theory employs aspiration levels, resource allocation decisions and "satisficing". Aspiration levels are reflected in firm strategies that reflect prior decisions, and PI resource allocation and development decisions are based on comparisons of performance and aspiration levels (Cyert & March, 1963). Winter (2000, p. 983) notes that "satisficing", a form of non-maximizing decision-making, influences the level of a firm's PI capability development. Contingency theory notes that when product concepts are selected as product inventions/adoptions, resources are allocated to support those PI decisions (Kessler, 2004). PI decisions are part of strategy-making that can be viewed as an "iterated

process of resource allocation" (Noda & Bower, 1996, p. 159). Real options theory involves PI investment decisions that result in capability development (McGrath & Nerkar, 2004). While aspects of two corporate governance theories, agency and transaction cost economics, are implicit in some forms of PI decision-making, they are not included in the PI theoretical framework because their respective units of analysis, principal-agent relationship contract (Eisenhardt, 1989) and transaction (Williamson, 1975), differ from this paper's unit of analysis, the firm that shapes and supports its PI process (Murmann et al., 2003; Wolfe, 1994).

Resources/Capabilities

Supported by the evolution, intelligence, and decision-making building blocks, the resources/capabilities theoretical building block (see Table 2, Box T-4) relies on the RBV and dynamic capabilities theories (Barney, 1991; Teece et al., 1997). These theories explain that resources are reconfigured imaginatively by capabilities (processes; see Box P-4) into unique resource combinations (see Box O-4) that fulfill management intentions/aspirations for competitive advantage (see Box D-4) and superior performance (Amit &Schoemaker, 1993; Becker, Knudsen & March, 2006; Kogut & Zander, 1992; Eisenhardt & Martin, 2000; Schumpeter, 1927). The development of these novel resource combinations concurrently develops firm capabilities necessary for sustained competitive advantage (Danneels, 2002; Winter, 2000).

Product inventions/adoptions/commercializations (see Boxes O-3 and O-4) can be thought of as novel resource configuration streams that are manipulated by the firm's dynamic capabilities that evolve through organizational learning, and provide long-term competitive advantages to the firm (Eisenhardt & Martin, 2000; Teece et al., 1997). As "well-established routines," dynamic capabilities serve as "building blocks for novel recombinations" (see Boxes P-4 and O-4; Levinthal, 2006, p. 393; Nelson & Winter, 1982). RBV theory views the firm as a

bundle of resources, made up of tangible and intangible assets from which heterogeneous services can be obtained that persist over time (Amit & Schoemaker, 1993; Barney, 1991; Penrose, 1959; Wernerfelt, 1984). The RBV's VRIN (valuable, rare, inimitable, nonsubstitutable) criteria for sustained competitive advantage remain applicable to resources but not to dynamic capabilities, as the latter are often subject to best practices diffusion that violate VRIN criteria (Eisenhardt & Martin, 2000). However, dynamic capabilities are critical to RBV theory to avoid the tautology that arises when scholars attribute firm superior performance observed to the unique resources then held by that firm (Eisenhardt & Martin, 2000; Priem & Butler, 2001). Due to differing levels of analysis, network theory (Gulati, 1998) and alliance portfolio theory (Lavie, 2007) are excluded from the PI theoretical framework regarding resources/capabilities.

Summary

Overall, the four PI theoretical building blocks explain the three PI domains of decision-making, processes and outputs. (See Table 2.) The evolution theoretical building block, with its focus on path dependence, path creation, VSR processes, and coevolution, elucidates PI decision-making and PI processes (see Table 2, Boxes D-1 and P-1). The evolution building block alone does not address PI outcomes since PI outcomes require intelligence. The three remaining theoretical building blocks explicate all three PI domains: intelligence theoretical building block comprised of organizational learning, rational search and knowledge management theories (see Boxes D-2, P-2, O-2); the decision-making theoretical building block made up of limited rationality, contingency and real options theories (see Boxes D-3, P-3, O-3); and the resources/capabilities theoretical building block composed of RBV and dynamic capabilities theories (see Boxes D-4, P-4, O-4). By applying the four theoretical building blocks to PI theory, a PI decision-making framework can be developed that is integrated with the various PI processes.

PRODUCT INNOVATION DECISION-MAKING AND PROCESSES

Product Innovation Decision-Making Approaches

PI decision-making by the firm presumes the existence of an organizational strategy that seeks to achieve and maintain sustained competitive advantage, supported by a subordinate PI strategy that promotes product innovation in the form of novel resource configurations (Adams et al., 2006; Eisenhardt & Martin, 2000). Both the firm's overall and PI strategies are the products of historical, resource/capabilities development paths that are unique to each firm (Damanpour, 1991; Wolfe, 1994).

In the realm of PI decision-making, scholars have taken two routes. One approach is to focus on the product adoption decision, which takes place when the firm chooses a product concept in the form of a product invention/adoption and commits to its further development. There are several criticisms to this approach: (1) PI actions can take place without PI decisions being made; (2) PI decisions announced for organizational benefit can be made without any intention of fulfilling them; and (3) PI decisions made with the intention of fulfilling them may not be carried out because the situation changes (Wolfe, 1994). Hence, "it is more important to know what an organization does (implementation) than what it has decided to do (adoption)" (Wolfe, 1994, p. 417).

The second decision-making approach is not to focus explicitly, but rather implicitly, on PI decisions through the myriad of external and internal contingency factors that act as PI determinants (Wolfe, 1994). Reviews of the PI literature have not identified any dominant determinants but point to their heterogeneity (Crossan & Apaydin, 2010; Wolfe, 1994); for example, Damanpour (1991) identifies the primary contingency factor as the type of organization, suggesting that PI, as a firm-specific process, is not amenable to generalizability

across organizations (Wolfe, 1994). Another shortcoming of the second approach is that PI determinants are often used to predict various types of product commercializations, e.g., incremental versus radical, where the model that results from this approach explicitly identifies external and internal contingency factors that *may* determine an organization's PI decisions (*unidentified*) that, in turn, are carried out in PI processes (*in manners unspecified*) to produce various kinds of product commercializations, an ambiguous approach that is similar to the "black box" of organizational demography criticized by Lawrence (1997). This vague approach is rejected in favor of a decision-making framework that focuses on PI processes rather than PI outcomes and employs major contingency factors that apply to most firms.

Product Innovation Decision-Making Major Contingency Factors

This section focuses on factors that influence PI decisions that precede the PI process, concurring with Wolfe (1994) that the focus should be on PI implementation, i.e., process. Avoiding the myriad of PI determinants that often are firm-specific, two major contingency factors are chosen that apply to all organizations. In his review of the innovation management literature, Tidd (2001) identifies two contingency factors, uncertainty and complexity, as having the greatest influence on innovation management. Tidd's (2001) view parallels Amit and Schoemaker's (1993) broader perspective that uncertainty and complexity are two key factors in firm decision-making regarding resources and capabilities.

Two opposite approaches have been taken regarding uncertainty faced by the firm. The first approach is fragmentation into many sub-categories: exogenous uncertainty that includes complexity, dynamism, and environmental munificence that incorporates resource acquisition and technological change; and endogenous uncertainty that includes entrepreneurial, managerial, organizational change, organizational learning, and organizational slack that encompasses

resource allocation and application (Aldrich, 1999; Cyert & March, 1963; Dess & Beard, 1984; Levinthal & March, 1993; Penrose, 1959; Pfeffer & Salancik, 1978; Szulanski, 1996; Tushman & Anderson, 1986).

The second approach aggregates the many facets of environmental uncertainty into one meta-construct, "strategic uncertainty" (Daft, Sormunen & Parks, 1988; Hoffmann, 2007). Strategic uncertainty, encompassing both exogenous and endogenous uncertainty, is defined as the "uncertainty perceived by the firm's senior executives concerning the consequences of strategic decisions resulting from unclear environmental developments" "in relevant environmental sectors, weighted with the perceived relative importance of the individual sectors" (Hoffmann, 2007, p. 83). Given that firm executives' perceived relative importance is connected with the firm's aspiration levels, strategic uncertainty can be seen as influenced by firms' heterogeneous aspirations, manifested implicitly in the past experiences of firm executives, as well as developed from firm historical and peer performance, and explicitly stated in the strategies they develop (Cyert & March, 1963; Greve, 2003; Winter, 2000). Hoffmann (2007) finds that under perceived conditions of high strategic uncertainty, firms will tend to pursue exploration strategies, while under perceived conditions of low strategic uncertainty, organizations will tend to pursue exploitation strategies.

The fragmented approach to uncertainty appears designed to repeat the heterogeneous results that PI determinants research has obtained, thus requiring PI theory to be firm-specific. Instead, the aggregate approach employing strategic uncertainty appears applicable to most types of firms and is adopted as one major contingency factor in PI decision-making. Since firms pursue learning to reduce their uncertainty (Cyert & March, 1963), strategic uncertainty can be best explained using the intelligence theoretical building block.

Regarding the second major contingency factor, complexity is "a function of technological and organizational interdependencies" (Tidd, 2001, p. 175), and seen as the firm's efforts to develop technological (e.g., R&D) and other (e.g., market orientation) capabilities required for product commercialization (Crossan & Apaydin, 2010). The uncertainty faced by the firm in building capabilities, including the returns from its developmental efforts, is incorporated within strategic uncertainty (Danneels, 2008; Winter, 2000.) Helfat and Peteraf's (2003) "capability life cycle" captures the heterogeneity among firm resources and capabilities and articulates a sequential process: a founding stage of endowed resources/capabilities, a building stage where capabilities are developed, and a maturity stage where capabilities are maintained. Following the maturity stage, capabilities may be retired, retrenched where capabilities gradually decline, renewed where capabilities are improved, replicated in another geographic market, redeployed into another product market, and recombined with another capability, all of which are different courses of action that respond to two types of selection effects, the threat of capability obsolescence and the opportunity for capability growth or change (Helfat & Peteraf, 2003). Slack resources are essential for capability development because their presence is necessary for the firm to enact its PI decisions (Cyert & March, 1963; Greve, 2003). Capability development is therefore adopted as the second major contingency factor and is explained by the resources/capabilities theoretical building block. Therefore, PI decision-making by the firm is influenced jointly by interaction of its strategic uncertainty and capability development levels. (See Figure 1.) Assuming that each phase in the overall PI process is preceded by a key PI decision to initiate phase activities, the PI process phases, once identified, will reveal the necessary PI decisions.

Insert Figure 1 about here

Product Innovation Process

In general, there has been little theoretical basis for describing the overall PI process as a sequence of critical activities. Scholars have described varying numbers of activities that comprise PI, ranging from two (Knight 1967) to ten (Wolfe 1994). Instead of debating the merits of each PI sequence, we adopt an evolutionary process framework that employs the evolution theoretical building block. By employing the evolutionary stages of variation, selection, replication and retention (Campbell, 1965; Zollo & Winter, 2002), we determine the logical sequence, or path, of various PI activities into four phases that culminate in product commercialization. (Due to space limitations, we omit a coevolutionary view of the PI process which entails embedded VSR processes at levels above and below the organization.) We also apply the PI theoretical framework distinctions to delineate each of the four PI process phases. (See Table 1.) Coinciding with the four variation-selection-replication-retention evolutionary phases, PI decision-making consists of four key antecedent decisions: product variation, product selection, product replication and product retention. (See Figure 1.)

Product Variation Decision

A firm starting the PI process for the first time or in a new area does so to address a gap in the performance of an existing product or an opportunity to introduce a new product in one or more product markets (Kessler, 2004). As it begins, this firm faces high strategic uncertainty and low capability (Danneels, 2002; Hoffmann, 2007). A firm facing high strategic uncertainty can exploit its existing resources and wait to develop new resources and capabilities when uncertainty has been reduced, or explore by changing its resource configurations to take advantage of opportunities created by changing environments (Hoffmann, 2007). However, the exploit-and-wait option is not available when the firm is at a low level of capability development; hence, the

only viable option available to the firm is to explore, provided slack resources exist (Cyert & March, 1963; Greve, 2003; Hoffmann, 2007). In addition to contingency theory, firm product variation decisions to explore can be explained by limited rationality theory because firm PI performance levels are lower than their target aspiration levels, assuming slack resources exist (Cyert & March, 1963; March, 2008; March & Simon, 1958). Also, real options theory explains the firm's willingness to invest in exploration because its strategic uncertainty is high and the firm's reduction of such uncertainty via learning in the form of exploratory investments, the "R" in "R&D", act as valuable real options (Bowman & Hurry, 1993; McGrath & Nerkar, 2004).

The product variation decision to explore often involves firm investments that develop firm absorptive capacity that, in turn, recognizes, values and assimilates relevant external knowledge (Cohen & Levinthal, 1990; Nemanich, Keller & Vera, 2007). The generation of new product concept alternatives furthers the development of new capabilities, imitation of other firm capabilities, or changing existing capabilities (Danneels, 2002). Capability development in the variation phase often emphasizes technological capabilities (Kessler, 2004) since "exploration capabilities are derived primarily from a technological resource base" (Yalcinkaya, Calantone & Griffith, 2007, p. 83); and better-defined product concept technological characteristics can determine existing and new market opportunities (Bower & Christensen, 1995), as well as promote economies of scope so that capabilities can be exploited in multiple product markets (Danneels 2007; Hamel & Prahalad, 1989). (See Table 1 and Figure 1.)

> *Proposition 1: When firm strategic uncertainty is high, capability development is low, and slack resources exist, organizations will tend to make product variation decisions that begin the exploratory portions and variation phases of their PI processes, characterized by firms making investments in their absorptive capacity to explore various product concept alternatives through developing new capabilities, imitating other firms' capabilities, or changing their existing capabilities.*

Product Innovation Process Variation Phase

PI variation generates product concept alternatives, identified internally or externally, that emerge by blind or random changes (Campbell, 1965) or through deliberate actions based on past experience (Volberda & Lewin, 2003). PI activities involved in variation include "idea conception" (Becker & Whisler, 1967; Daft, 1978; Wolfe, 1994); "idea generation" (Knight, 1967; Ogburn, 1928; Shepard, 1967; Utterback, 1971), and "initiation" (Crossan & Apaydin, 2010; Kessler, 2004).

The variation phase of the PI process can be best explained using the intelligence theoretical building block comprised of organizational learning, rational search and knowledge management theories. (See Table 1.) Crossan et al. (2011) apply the 4I (intuiting-interpreting-integrating-institutionalizing) theory of organizational learning to PI by starting where all organizational learning and subsequent knowledge begin – with the individual – which are further developed through social interaction (Crossan et al., 1999; Cyert & March, 1963; Nonaka, 1994). Intuiting happens when individuals identify product concept alternatives that do not fit within mental models held by organizational members or do not fit with established organizational routines (Crossan et al., 2011). These product concept alternatives reflect PI variations resulting from knowledge acquisition (Crossan et al., 1999) and forgetting (Easterby-Smith & Lyles, 2011). Rational search theory views knowledge acquisition as the result of knowledge search and discovery that is linked to exploration (Gavetti & Levinthal, 2000; Rosenkopf & Nerkar, 2001).

Knowledge management theory views knowledge acquisition as requiring absorptive capacity, "the ability to evaluate and utilize outside knowledge [that] is largely a function of the level of prior related knowledge" (Cohen & Levinthal, 1990, p. 128), and a capability that allows the firm to recognize the value of new external knowledge, assimilate it, transform it, apply it,

and exploit it for commercial purposes (Todorova & Durisin, 2007). The development of absorptive capacity is domain-specific and path-dependent (Cohen & Levinthal, 1990; Levinthal & March, 1993). The firm's preferential investment in absorptive capacity promotes exploration (Nemanich et al., 2007). In terms of rational search, limited rationality and organizational learning, absorptive capacity represents the fruits of past knowledge searches as well as experiential learning that support exploration's product invention/adoption outcomes and promotes exploitation's product commercialization outcomes. Absorptive capacity provides evolutionary variation by facilitating combinations of old and new ideas while promoting selection and retention by serving as organizational memory of experiential learning why past variations were selected (Walsh & Ungson, 1991). (See Table 1.) Hence, *variation is the phase of the firm's overall PI process that acquires, assimilates and applies knowledge new to the firm to identify valuable, internally-generated or externally-adopted product concept alternatives.*

Product Selection Decision

Through the firm's exploratory efforts in the variation phase, its capabilities are enhanced from a low to a moderately low level, while strategic uncertainty is reduced from a high to a moderately high level (Hamel & Prahalad, 1993). The firm's capability building also generates product concept alternatives, some internally sourced, others externally acquired. If one or more of these product concept alternatives meet or exceed minimum performance thresholds based on external technological/market knowledge and internal experience, the firm is prepared to make its product selection decision (Henderson & Stern, 2004; Winter, 2000). If none of the product concept alternatives meet minimum performance thresholds, the firm makes another product variation decision and restarts the variation phase (see Figure 1), in line with Arthur's (2007, p. 275) description of product invention as "recursive problem solving." In addition to contingency

theory, limited rationality explains the product selection decision in terms of PI performance remaining below target aspiration levels, i.e., lack of existing product candidate (Cyert & March, 1963; Greve, 2003; Winter, 2000). Real options theory explains that additional investments, made in "R" (research) during the selection phase, add to the real options created during the variation phase, thus part of an options chain that reflects the firm's pursuit of a product strategy (Bowman & Hurry, 1993). Hence, the product selection decision is not a single choice over the most valuable product concept alternative but represents a bundle of interrelated decisions, e.g., who to assign to what project teams, how scarce resources will be allocated, that include proactive design choices that enable PI as well as reactive behavioral decisions that execute PI (Kessler, 2004). The product selection decision also represents political success that involves decision-making criteria, assignments of roles and responsibilities and, ultimately, power (Kessler, 2004). This decision leads to the selection phase where external and internal selection criteria are applied to the various product concept alternatives to identify internally-sourced product inventions and externally-sourced product adoptions (Burgelman, 2002; Henderson & Stern, 2004). The firm continues its exploration by making further investments in its absorptive capacity, emphasizing the application of knowledge gained during the variation phase for commercial purposes (Cohen & Levinthal, 1990; Nemanich et al., 2007). (See Table 1 and Figure 1.)

> *Proposition 2: When firm strategic uncertainty is moderately high, capability development is moderately low, and slack resources exist, organizations will tend to make product selection decisions that continue the PI process exploratory portions and start their selection phases, characterized by firms making investments in their absorptive capacity to select among various product concept alternatives to identify one or more product inventions/adoptions as potential candidates for product development.*

Product Innovation Process Selection Phase

PI selection evaluates and chooses the "best" internally-generated or externally-adopted product concept alternatives, using such criteria as internal competition for scarce resources, or

knowledge based on past experience that vicariously anticipates selection by the competitive external environment (Volberda & Lewin, 2003). Internally-generated product concept alternatives that are selected become product inventions, while selected externally-adopted product concept alternatives become product adoptions. PI activities involved in selection include "idea adoption" (Becker & Whistler, 1967; Daft, 1978; Knight, 1967; Wolfe, 1994), "invention" (Maclaurin, 1953; Utterback, 1971), and "selection" (Crossan & Apaydin, 2010; Kessler, 2004). Here the firm makes serious resource commitments to develop the selected product inventions and product adoptions (Burgelman, 1991).

The PI selection phase can also be illuminated using the intelligence theoretical building block. In terms of organizational learning theory, Crossan et al.'s (2011) 4I interpreting is performed by the individual who shares product concept alternatives with the group who, in turn, further grasps and evaluates the product concept alternatives. (See Table 1.) As a result of the group's further exploration and knowledge search (Rosenkopf & Nerkar, 2001), interpreting yields product concept selections that become product inventions/adoptions. Absorptive capacity represents synergistic knowledge among organization members (Cohen & Levinthal, 1990) that results in various outputs such as product inventions (Lane, Koka & Pathak, 2006). Hence, the accrued knowledge in absorptive capacity can be viewed as a repository of the firm's internal and external selection criteria (Henderson & Stern, 2004). Thus, *selection is the phase of the firm's overall PI process that chooses, for product development, the most valuable product inventions/adoptions among internally-generated and externally-adopted product concept alternatives identified through variation.*

Product Replication Decision

Product invention/adoption in the selection phase further reduces firm strategic uncertainty, especially its technological uncertainty, to moderately low levels, while building its capabilities, primarily technological, to moderately high levels. Given product invention/-adoption technological characteristics, a firm can better envision existing and new market opportunities for product commercialization (Bower & Christensen, 1995). Contingency theory explains the product replication decision as the firm tending to exploit its capabilities when it faces reduced strategic uncertainty (Hoffmann, 2007). Limited rationality theory argues that the product replication decision results from PI performance levels (manifested in the selected product candidate) meeting or slightly exceeding target aspiration levels (Cyert & March, 1963; Greve, 2003). Real options theory explains the product replication decision as equivalent to the firm exercising "in the money" technological real options made during the variation and selection phases because technological uncertainty has been reduced, but extending the option chain by investing in marketing real options because its marketing uncertainty is still high (Bowman & Hurry, 1993; McGrath & Nerkar, 2004).

The aim of product replication is to gain market learning experientially as the "development of exploitation capabilities is primarily derived from a marketing resource base" (Yalcinkaya et al., 2007, p. 83). The replication phase of the PI process features reproduction of the selected product invention/adoption in various product markets, where experiential learning gained there allows the firm to further develop that product (Winter & Szulanski, 2001). Experiential market learning creates marketing capabilities that are complementary assets (Stieglitz & Heine, 2007). Complementary assets are resources that increase the marginal returns of other related assets, e.g., movie studios and cinemas (Lachmann, 1947; Stieglitz & Heine, 2007). Complementary assets consist of tangible assets (e.g., manufacturing and marketing capabilities,

distribution channels) and intangible, capitalized assets (e.g., patents granted, strategic alliances) that increase the appropriability of product commercialization profits (Teece, 1986; Tripsas, 1997). Hence, the firm's decision to enter the product replication phase of the PI process is a decision to invest in complementary assets (Nemanich et al., 2007). If the firm is unsuccessful in its product replication efforts, then it makes another product selection decision to restart the PI process selection phase. If there are no other viable product concept alternatives to select from, then the firm restarts its PI process variation phase. (See Table 1 and Figure 1.)

> *Proposition 3: When firm strategic uncertainty is moderately low, capability development is moderately high, and slack resources exist, organizations will tend to make product replication decisions which begin the exploitative portions and replication phases of their PI processes, characterized by firms making investments in their complementary assets needed to develop their selected product inventions/adoptions in target product markets.*

Product Innovation Process Replication Phase

PI replication is the evolutionary stage between selection and retention that includes knowledge sharing/transfer, experimentation and problem solving, where product inventions/-adoptions are developed by applying them in different product-market contexts, thereby experientially generating new learning requiring significant cognitive efforts to analyze, and often causing routines to be modified or new ones created (Van de Ven & Polley, 1992; Winter & Szulanski, 2001; Zollo & Winter, 2002). The major PI activity involved in replication is "development" (Crossan & Apaydin, 2010; Ogburn, 1928) that may include trials and production (Zaltman et al., 1973).

The PI replication phase can be better explained using the intelligence theoretical building block. Crossan et al.'s (2011) 4I integrating of product inventions/adoptions into the organization requires that the group achieve shared understanding and take coherent, collective actions that ignore or modify relevant organizational routines so that the product

invention/adoption can be further developed. Integrating requires replicating (developing) product inventions/adoptions in different possible product markets, a trial-and-learning process that reflects exploitation (Winter & Szulanski, 2001). (See Table 1.) Rational search theory explains how experiential learning from replication (development) is linked to exploitation (Gavetti & Levinthal, 2000; Rosenkopf & Nerkar, 2001). Such exploitation is enabled by the firm's absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2002). While absorptive capacity helps the firm to create PI value (Tsai, 2001), complementary assets helps the firm appropriate PI value (Teece, 1986). The firm's preferential investment in complementary assets promotes exploitation (Nemanich et al., 2007). Levinthal and March (1993, p.106) note that a firm's "return from any particular innovation" is "partly a function of an organization's experience with the new idea" (invention). Thus, the employment of complementary assets produces experience (experiential learning) that is tied to these tangible and capitalized assets.

Other scholars have valued the role that complementary assets serve in innovation, especially the link between complementary assets and exploitation (Mitchell, 1989; Nemanich et al., 2007; Tripsas, 1997). Arora and Ceccagnoli (2006) assert that complementary assets intervene between product invention and product commercialization, an exploitative role supported by others (e.g., Stieglitz & Heine, 2007; Teece, 1986). Stieglitz and Heine (2007, p. 13) emphasize the role of complementary assets in exploiting newly created knowledge in firm innovation, and observe that firm strategic direction is needed to "coordinate complementary learning processes that lead to the creation of new assets," supporting this paper's conclusion that experiential learning in the PI process reflects the experience that is embodied in complementary assets. (See Table 1.) Hence, *replication is the phase of the firm's overall PI process that improves product invention/adoptions by applying them in a variety of different*

contexts (e.g., product-market), in ways that generate experiential learning for the firm to maximize its value creation and appropriation.

Product Retention Decision

During the PI process replication phase, reproduced product inventions/adoptions further reduce the firm's strategic uncertainty, especially its marketing uncertainty, to low levels, while building its capabilities, primarily marketing, to high levels. (See Table 1 and Figure 1.) Contingency theory asserts that in this low-uncertainty (high-confidence) and high-capability position, and armed with specific product-market information regarding the likelihood of its product success, the firm can make its product retention decision to begin its efforts to commercialize, and fully exploit that product (Hoffmann, 2007). Limited rationality theory argues that the product replication decision results from PI performance levels (manifested in the replicated product invention/adoption) meeting or slightly exceeding target aspiration levels (Cyert & March, 1963; Greve, 2003). Real options theory explains that marketing real options created during replication are exercised when marketing uncertainty levels are sufficiently reduced (McGrath & Nerkar, 2004). Real options theory explains the product retention decision as equivalent to exercising "in the money" marketing options (Bowman & Hurry, 1993; McGrath & Nerkar, 2004).

The retention phase of the PI process features the introduction of the developed product invention/adoption into target product markets, where experiential learning gained there allows the firm to optimize its marketing mix for that product based on customer feedback (Danneels, 2003). Such market experiential learning further develops marketing capabilities that are complementary assets (Stieglitz & Heine, 2007). Hence, the firm's decision to enter the PI process retention phase is a decision to invest in complementary assets (Nemanich et al., 2007). If the firm is unsuccessful in its product commercialization efforts, then it makes another product

replication decision to restart the PI process replication phase. If there are no other viable product inventions/adoptions to develop, then the firm makes another product selection decision to restart it PI process selection phase. (See Figure 1.) If the product invention/adoption selected is very different from the products currently offered by the firm, the product retention decision may lead to a business design decision, whereby the firm establishes a relatively autonomous business venture that can more effectively commercialize that product than the firm's existing primary business unit (Tushman & O'Reilly, 1996). (See Table 1 and Figure 1.)

> *Proposition 4: When firm strategic uncertainty is low, capability development is high, and slack resources exist, organizations will tend to make product retention decisions that continue the exploitative portions and start the retention phases of their PI processes, characterized by firms making investments in complementary assets needed to commercialize their selected product inventions/adoptions in target product markets.*

Product Innovation Process Retention Phase

PI retention preserves "positively selected variants" (Campbell, 1965, p. 27), exemplified by the firm's launches of its developed product inventions/adoptions into target product markets, product launches that demand large resource commitments by the firm. PI activities involved in retention include "innovation" (Maclaurin, 1953), "implementation" (Kessler, 2004; Shepard, 1967; Utterback, 1971; Wolfe, 1994), and "commercialization" (Crossan & Apaydin, 2010).

The PI retention phase can be best illuminated through the intelligence theoretical building block. Crossan et al.'s (2011) 4I institutionalizing reflects the organization's acceptance of the product invention/adoption through its formal changes to existing organizational routines that make the developed product inventions/adoptions required, repeatable, and commercialized. (See Table 1.) This institutionalizing requires the firm's retention of the commercialized products based on experiential learning gained through exploitation (Zollo & Winter, 2002). Rational search theory asserts that during retention's exploitation, the firm does

not search for new knowledge but instead learns experientially from the successes and failures of its product commercializations (Gavetti & Levinthal, 2000; Rosenkopf & Nerkar, 2001). Knowledge management theory explains that during retention, the firm's relevant absorptive capacity helps it exploit its product inventions and adoptions through commercialization while the firm's pertinent complementary assets help it appropriate the most value from product commercialization (Cohen & Levinthal, 1990; Teece, 1986). Hence, *retention is the phase of the firm's overall PI process that commercializes developed product inventions/adoptions in ways that maximize firm value appropriation.*

Post-Commercialization Aftermath

When the firm commercializes its product invention/adoption, its strategic uncertainty is low and its capability development is high. Notwithstanding its efforts to "tweak" its product launch activities via marketing mix changes (Danneels, 2003), the firm will tend to exploit and thereby suspend its PI process efforts for that product. Over time, such inactivity will tend to increase the firm's strategic uncertainty and decrease its capability development levels with respect to that target product market. At this point, the firm can pursue one of two options. It may elect to make another product refinement decision and restart its PI process development phase with the aim to generate another product that can succeed its commercialized product. Alternatively, it can decide to cannibalize its commercialized product by diverting resources and capabilities to producing new product inventions/adoptions suitable for development and commercialization (Chandy & Tellis, 1998; Danneels, 2008; Henderson & Stern, 2004). As the firm's strategic uncertainty reaches high levels while its capability development falls to low levels, the firm is motivated to restart the PI process from the beginning (Helfat & Peteraf, 1993; Hoffmann, 2007). (See Figure 1.)

DISCUSSION

Theoretical Implications

This paper integrates PI theory by successfully uniting the three PI domains of decision-making, processes and outcomes, overcoming cross-domain barriers found in the PI literature (Crossan & Apaydin, 2010; Wolfe, 1994). The four PI decisions of product variation, product selection, product replication, and product retention are explained using the three decision-making theories of contingency, limited rationality and real options. (See Table 1.) The four PI decisions start four similarly-named phases of the evolutionary PI process. Two of the four PI process phases produce three PI outputs, selection generating two intermediate outputs of product invention (internally sourced) and product adoption (externally sourced), and retention achieving a final output of product commercialization.

The contingency framework that explains PI decision-making focuses on the firm's PI implementation rather than its PI adoption decision, focusing on what PI is actually done by the firm rather than what the firm intends to do in PI (Wolfe, 1994). This framework adopts two major contingency factors, strategic uncertainty and capability development, that avoid the myriad of PI determinants that are often firm-specific and render most PI theories ungeneralizable (Crossan & Apaydin, 2010).

The four PI process phases parallel the evolutionary stages of variation, selection, replication and retention (Campbell, 1965; Zollo & Winter, 2002), the first two PI process phases comprising the PI process' exploratory portion and the last two its exploitative portion (March, 1991). (See Table 1.) The exploratory portion involves the firm allocating most of its resources to developing its absorptive capacity while the exploitative portion involves the firm allocating most of its resources to enhancing its complementary assets (Nemanich et al., 2007). The

integrated PI theory demonstrates how exploration and exploitation can be balanced by the firm in two ways: (1) temporally along a product development trajectory; and (2) across product development trajectories (Gupta et al., 2006).

The three PI outputs of product invention, product adoption and product commercialization are defined and held distinct from each other as well as separate from the overall PI process. PI theoretical clarity is well served by avoiding conflation of key outputs often found in the literature (Arthur, 2007; Crossan & Apaydin, 2010; Fleming, 2001).

"Product innovation functions as a tool for organizational learning, and thus contributes to firm renewal" (Danneels, 2002, p. 1097). It is clear from the discussion above that organizational learning, along with rational search and knowledge management, are intertwined with the PI process phases. Note that exploration begins with variation and ends with selection, while exploitation begins with replication and ends with retention (Zollo & Winter, 2002). (See Table 1.) Exploration corresponds with individual intuiting and group interpreting of new product concept alternatives, while exploitation is associated with group and organizational integrating of product inventions/adoptions and organizational institutionalizing of its commercialized products (Crossan et al., 2011). During exploration, the firm's absorptive capacity is developed through knowledge search while during exploitation the firm's absorptive capacity is applied, as are its complementary assets that are developed through experiential learning (Nemanich et al., 2007; Stieglitz & Heine, 2007).

The major theoretical implication of this paper's integrated PI theory is a conceptual framework. (See Figure 2.) The evolution theoretical building block contributes two theoretical constructs, internal and external selection environments, as well as the framework's underlying path-dependent/creation, variation-selection-replication-retention processes. The intelligence

theoretical building block contributes two theoretical constructs, absorptive capacity and complementary assets as knowledge/experience-laden intermediate products of the PI process, where the development of absorptive capacity is a prerequisite of product invention/adoption and the application of absorptive capacity and the development/application of complementary assets are needed for product commercialization. The decision-making theoretical building block contributes the strategic decision-making construct that is the recipient of performance feedback loops from the seven other constructs (not shown in Figure 2 for clarity purposes) and drives the firm's resource allocations. The resources/capabilities theoretical building block contributes the remaining three constructs: resources, product invention/adoption, and product commercialization.

Insert Figure 2 about here

Faced by high strategic uncertainty (external selection environment [ESE]) and low capability development (internal selection environment [ISE]), while PI performance level is below its target PI aspiration level where slack resources are present (ISE), and motivated to create technological real options because of such high uncertainty (ISE/ESE), the firm will tend to make its product variation decision to begin its PI process variation phase. During variation, the firm allocates resources to develop its absorptive capacity as it internally and externally generates variations in product concepts. (See Figure 2.)

If successful PI process variation phase efforts reduce the firm's strategic uncertainty to a moderately high level (ESE) and increases its capability development to a moderately low level (ISE), while its PI performance level is below its PI target aspiration level where slack resources exist (ISE), and it continues to invest in technological real options, the firm will tend to make its product selection decision to begin its PI process selection phase. During selection, the firm

allocates resources to develop its absorptive capacity as it evaluates product concept alternatives. Such alternatives that meet internal/external success criteria (ISE/ESE) are recognized by the firm as product inventions/adoptions if internally/externally sourced. (See Figure 2.)

If successful PI process selection phase efforts yield product inventions/adoptions, thereby reducing the firm's strategic uncertainty to a moderately low level (ESE) and raising its capability development to a moderately high level (ISE), while its PI performance level meets or exceeds its target aspiration level where slack resources are present (ISE), and it is a position to "cash in" its technological real options while creating marketing real options, the firm will tend to make its product replication decision to begin its PI process replication phase. During replication, the firm applies its absorptive capacity and allocates resources to enhance its complementary assets as it replicates the selected product invention/adoption in various product markets. (Note in Figure 2 that the enhancement of complementary assets proceeding from product invention/adoption requires the prior development of absorptive capacity.)

If successful PI process replication phase efforts yield promising product markets for the replicated product invention/adoption, thereby lowering the firm's strategic uncertainty to a low level (ESE) and increasing its capability to a high level (ISE), while its PI performance level meets or exceeds its target aspiration level where slack resources exist (ISE), and it continues to invest in marketing real options, the firm will tend to make its product retention decision to begin its PI process retention phase. During retention, as it commercializes its product and refines its product marketing mix, the firm applies its absorptive capacity's technological/marketing knowledge while it continues to allocate resources to enhance its complementary assets and apply the experience embodied in them. (See Figure 2.)

Empirical Implications

Strategic uncertainty requires firm executive perceptual data, and can be measured using survey items previously employed to multiply perceived sector importance by the sum of perceived sector complexity and perceived sector change (Daft et al., 1988; Elenkov, 1997). Capability development can be measured in several ways, for example, perceptually measuring technological and commercial competence against strategic requirements (Hoffmann, 2007).

Investment in absorptive capacity is a clear indicator of exploration, while investment in complementary assets is an unambiguous indicator of exploitation (Koza & Lewin, 1998; Nemanich et al., 2007). Absorptive capacity investment has been operationalized in various ways, such as R&D intensity (Cohen & Levinthal, 1989, 1990), the number of exploratory alliances made (Koza & Lewin, 1998; Rothaermel & Deeds, 2004), and the number of technological acquisitions completed (Ahuja & Katila, 2001; Puranam, Singh & Zollo, 2006). Complementary asset investment has been operationalized in several ways, to include advertising intensity, capital investments, exploitative alliances and non-technological acquisitions (Ahuja & Katila, 2001; Mizik & Jacobson, 2003; Rothaermel & Deeds, 2004). Since firms often pursue both exploration and exploitation, a greater investment emphasis on absorptive capacity relative to complementary assets indicates a firm's choice for exploration, while a relatively greater investment emphasis on complementary assets would indicate an exploitative choice (Mizik & Jacobson, 2003; Puranam et al., 2006). Measures of exploration and exploitation choices reflect comparisons of investments to increase absorptive capacity relative to complementary assets and vice versa, e.g., the remainder of advertising expenses less R&D expenses divided by total assets (Mizik & Jacobson, 2003), the proportion of exploratory alliances to total alliances (Rothaermel & Deeds, 2004), and the ratio of technological acquisitions to total acquisitions (Ahuja & Katila,

2001). Given sufficient variation in firm internal and external selection environments, the PI theoretical framework's interrelationships are clearly testable.

Management Implications

There are three implications for managers that can be drawn from this paper. First, to optimally invest in their absorptive capacity and complementary assets, firms must understand their PI processes well enough to identify their several time-delayed, indirect cause-effect relationships. Next, realizing that absorptive capacity indirectly affects complementary assets (see Theoretical Implications above), firms cannot just focus on the downstream part of their value chains by pursuing product commercialization strategies, as neglecting their absorptive capacity will negatively affect their complementary assets. Finally, firms must consider their entire PI process when considering what portions of their value chain to outsource. Outsourcing too much of the upstream value chain leaves firms vulnerable to technological disruptions while outsourcing too much of the downstream value chain renders firms exposed to loss of appropriability of their innovation rents. These three implications point out that absorptive capacity and complementary assets require better management, which Lane et al. (2006) and Stieglitz and Heine (2007) respectively assert are important topics neglected by scholars.

Limitations and Implications for Future Research

This paper employs the variation-selection-replication-retention (VSRR) evolutionary cycle (Campbell, 1965; Zollo & Winter, 2002) but, due to space constraints, does not examine coevolutionary whole-part competition (Baum, 1999), where selection among variations at one level of analysis conflict with selections made at a higher level, e.g., product concept alternatives selected as product inventions/adoptions at the organizational level (internal selection environment) conflicting with product standards adopted at the market level (external selection

environment). Also, this paper did not examine interorganizational learning (Lane & Lubatkin, 1998) by restricting its focus to the organizational level of analysis. Further, the integrated PI theory did not incorporate either agency theory or transaction cost economics in its explanation of PI decision-making due to differing units of analysis. Finally, due to differing levels of analysis, network theory (Gulati, 1998) and alliance portfolio theory (Lavie, 2007) are excluded from the PI theoretical framework regarding resources/capabilities. Reflecting upon the aforementioned limitations, future PI research should extend to the interorganizational level of analysis to reflect greater PI collaboration among firms and within alliance networks, as well as adopt a coevolutionary approach that integrates lower- and higher-level VSRR processes into the firm's overall PI process' VSRR processes.

CONCLUSION

Firm-level product innovation (new product development) theory today is ambiguous, conflated, fragmented, incomplete, unbalanced, and inconsistent. However, extant product innovation scholarship contains all the ingredients needed for developing a theoretical framework that addresses each of these shortcomings and develops an integrated theory of organizational product innovation. This paper has taken the first step in developing a theoretical framework that explains the decisions, processes and outputs of firm product innovation. This paper's theory contributes to scholarship in distinguishing between the product innovation roles of: variation, selection, replication, and retention; exploration and exploitation; knowledge search and experiential learning; absorptive capacity and complementary assets; value creation and value appropriation; and product invention, product adoption, product commercialization, and product innovation. With these clear theoretical distinctions and integrating explanations, product innovation scholarship has the capability for further theoretical advancements and empirical discoveries.

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TABLE 1
Product Innovation (PI) Theoretical Framework Distinctions

PI decisions/process phases: PI theoretical building blocks and distinctions	**Variation**	**Selection**	**Replication**	**Retention**
Evolution	Product Variation	Product Selection	Product Replication	Product Retention
Decision-Making[1]				
• Contingency factors				
➢Strategic uncertainty	High	Moderately high	Moderately low	Low
➢Capability development	Low	Moderately low	Moderately high	High
• Limited rationality	PI performance levels below aspiration levels	PI performance levels below aspiration levels	PI performance levels at/above aspiration levels	PI performance levels at/above aspiration levels
• Real options	R&D investments (options)	R&D investments (options)	R&D options exercised Marketing investments (options)	Marketing options exercised
Intelligence				
• Organizational learning	Exploration Intuiting	Exploration Interpreting	Exploitation Integrating	Exploitation Institutionalizing
• Rational search	Knowledge search	Knowledge search	Experiential learning	Experiential learning
• Knowledge management	Absorptive capacity development	Absorptive capacity development	Absorptive capacity application Complementary assets development	Absorptive capacity application Complementary assets development/application
Resources and Capabilities				
• Value activity	Value creation	Value creation	Value appropriation	Value appropriation
• Output type		Product invention (internal) Product adoption (external)		Product commercialization

[1]Note: Assumes that organizational slack exists.

TABLE 2
Product Innovation (PI) Theoretical Building Blocks, Operative Theories and Three Domains

Level	Theoretical Building Blocks	PI Operative Theories (T)	PI Decision-Making (D)	PI Processes (P)	PI Outputs (O)
Level 4 (Top)	Resources/Capabilities	**T-4.** Resource-based view (RBV; Barney, 1991); and dynamic capabilities (Teece et al., 1997)	**D-4.** Pursuit of sustained competitive advantage (Eisenhardt & Martin, 2000)	**P-4.** Capabilities (Danneels, 2002); and dynamic capabil-ities (Eisenhardt & Martin, 2000; Teece et al., 1997)	**O-4.** Novel resource combi-nations (Kogut & Zander, 1992); product commercializa-tion (Eisenhardt & Martin, 2000)
Level 3	Decision-Making	**T-3.** Limited rationality (Cyert & March, 1963); contingency (Lawrence & Lorsch, 1967); and real options (McGrath, 1997)	**D-3.** Design and behavioral decisions (Kessler, 2004); high- or low-risk courses of action chosen based on gaps between performance and aspiration levels (Audia & Greve, 2006); and investment decisions as real options (McGrath & Nerkar, 2004)	**P-3.** PI initiation, selection and implementation stages (Kessler, 2004); R&D investment as real option (McGrath & Nerkar, 2004); and stimulated search (exploration) versus constrained search (exploitation) (March, 1991)	**O-3.** Incremental or radical innovation as low-risk or high-risk courses of action (Greve, 2002); product inven-tion or adoption as selection decision, and product com-mercialization as implemen-tation decision (Kessler, 2004)
Level 2	Intelligence	**T-2.** Organizational learning (Crossan et al., 1999; March 1991); rational search (Levinthal & March, 1993; March, 1991); and knowledge management (Nonaka, 1994)	**D-2.** Investment in absorptive capacity promotes explora-tion, investment in comple-mentary assets promotes exploitation (Nemanich et al., 2007); and PI resource allocation decisions (Bower, 1970; Cyert & March, 1963; March & Simon, 1958)	**P-2.** Rational search (March, 1991); experiential/vicarious learning (Gavetti & Levin-thal, 2000; Terlaak & Gong, 2008); exploration/exploita-tion (March, 1991); capability learning (Winter, 2000); guide dynamic capabilities evolution (Eisenhardt & Martin, 2000)	**O-2.** Absorptive capacity (Cohen & Levinthal, 1990); complementary assets (Trip-sas, 1997); patents (Levitas & McFadyen, 2009); product inventions (Arthur, 2007); knowledge part of products (Danneels, 2002); and organizational memory (Walsh & Ungson, 1991)
Level 1 (Bottom)	Evolution *Note: Higher-level theoretical building blocks are supported by lower-level theoretical building blocks.*	**T-1.** Evolution (Campbell, 1965; Nelson & Winter, 1982); coevolution (Lewin & Volberda, 1999); path crea-tion (Garud et al., 2010; Sy-dow et al., 2009); path depen-dence (Sydow et al.,	**D-1.** Escalation of commitment Burgelman, 2002); lock-in (Burgelman, 2002; Sydow et al., 2009); managed selection (Volberda & Lewin, 2003); and persistence (Burgelman, 1996)	**P-1.** Creative destruction (Schumpeter, 1934); recombi-nation of past knowledge (Kogut & Zander, 1992); technological 'lock-in' (Leo-nard-Burton, 1992); variation, selection,	**O-1.** None

2009; Vergne & Durand, 2010)	replication and re-tention (Zollo & Winter, 2002)

FIGURE 1
Process Innovation Decision-Making and Process Phase Framework

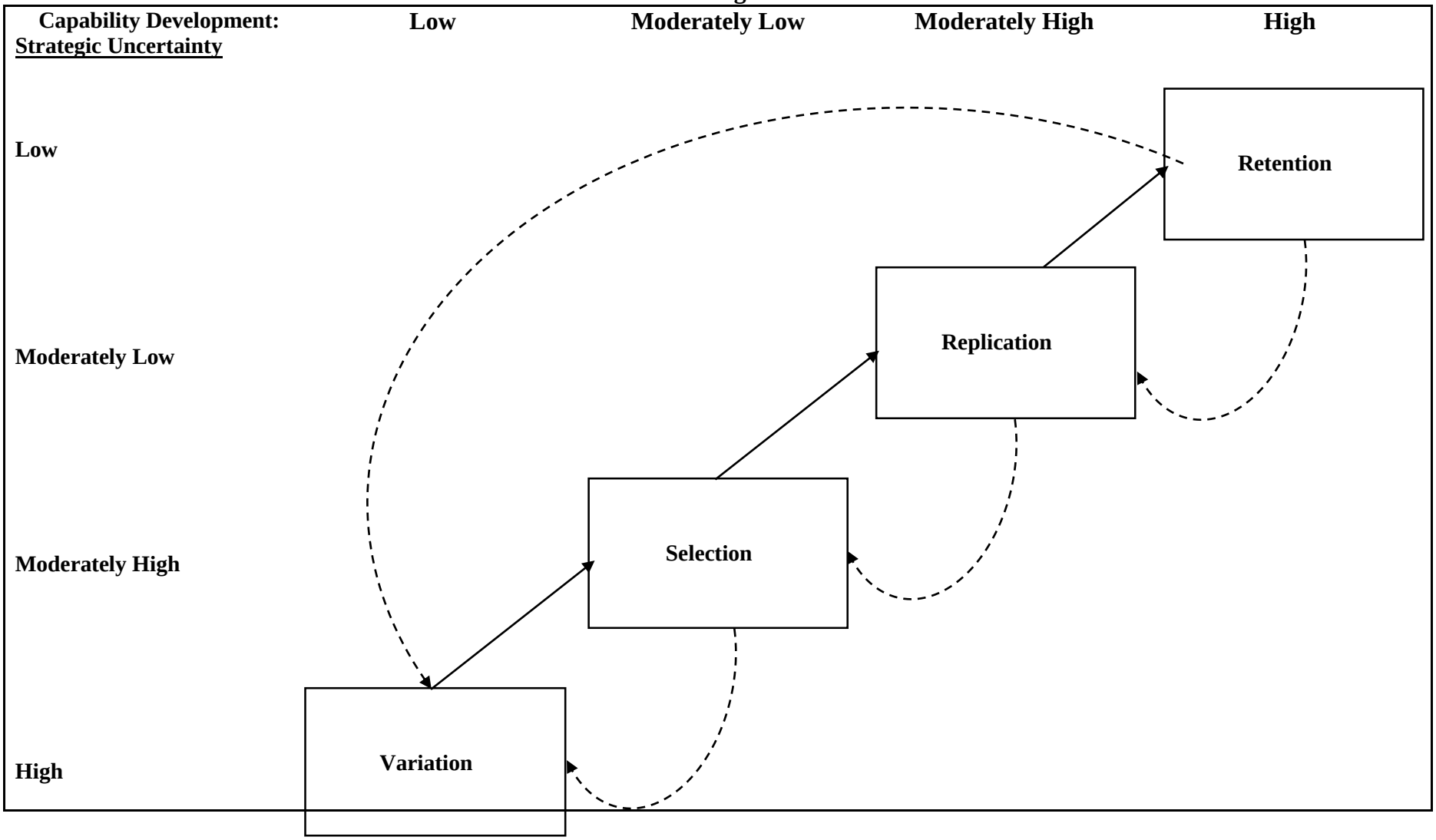
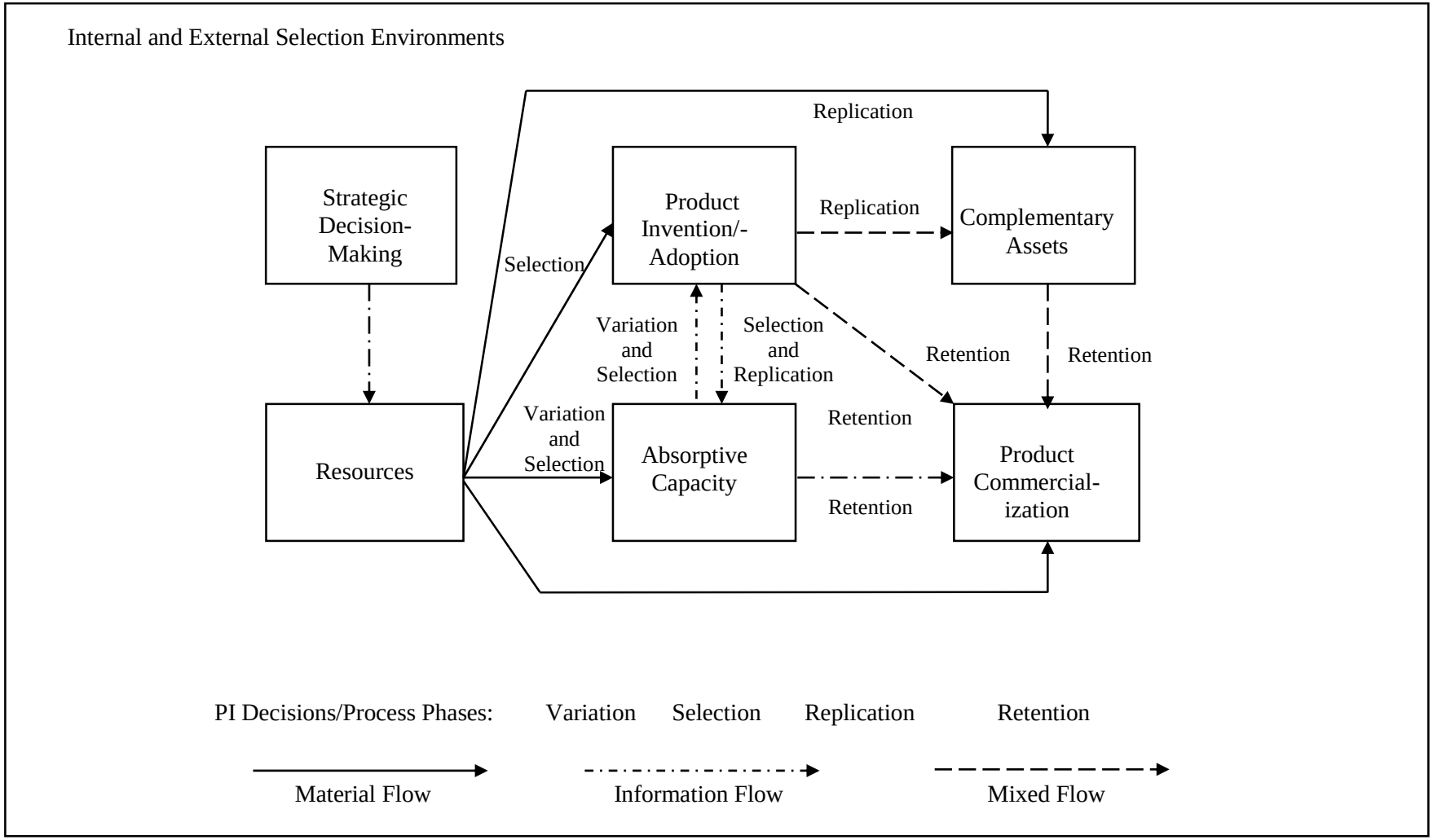


FIGURE 2
Integrated Product Innovation (PI) Theory Conceptual Framework



Note: Conceptual framework omits feedback loops to Strategic Decision-Making from all other constructs.