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Thinking Outside the Box: An Absorptive Capacity Approach to the Product Development Process

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Abstract

In high technology markets, the development of new products has received widespread interest among marketing and management scholars. Popular wisdom suggests that a consumer driven approach to the product development process is key to a firm's competitive success. Organizational learning research however has argued that a narrow focus on customer needs restricts a firm's ability to search for unconventional product market opportunities. Hence, a greater openness to external ideas that extend beyond the interests of the consumer has been called for. In drawing on concepts of absorptive capacity and strategic alliances, this study develops a conceptual model to examine a firm's product development process. This conceptual model is examined in the biotechnology industry. Regression analyses show a firm's absorptive capacity exhibits a positive yet diminishing effect on a firm's ability to introduce products to the market. Findings also indicate the type of knowledge possessed by a firm yields a distinct moderating effect to the product benefits of alliances.

Keywords: Organizational learning, absorptive capacity, alliances, and product innovation.

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In high technology markets, the development of new products has received widespread interest among marketing and management scholars (Eisenhardt and Martin 2000; Lane et al. 2006; Narver et al. 2004). This is because a firm's competitive advantage depends on its ability to continually develop product solutions that meet the changing needs of the consumer (Eisenhardt and Martin 2000; Jaworski and Kohli 1993; Slater and Narver 1995). This ability is widely attributed to a firm's "market orientation" which involves "…seek[ing] to understand customers' expressed and latent needs, and develop[ing] superior solutions to those needs" (Slater and Narver 1999, 1165). For instance, a firm who invests in its marketing expertise to assess the needs and preferences of its consumers will lead to more effective target marketing, product development and positioning (Benedetto 1999; Brown and Eisenhardt 1995). Various marketing studies have subsequently found that a firm's "market orientation" is positively associated with its performance (Han et al. 1998; Jaworski and Kohli 1993; Slater and Narver 1999; Zhou et al. 2005).

Yet, despite its general acceptance, there are nevertheless limits to this consumer driven approach (Christensen and Bower 1996; Hamel and Prahalad 1991 and 1994; Narver et al. 2004; Zhou et al. 2005). Christensen and Bower (1996) and Hamel and Prahalad (1991) argue that a narrow focus on customer needs restricts a firm's ability to search for unconventional product market opportunities. For instance, in Christensen and Bower's (1996) analysis of disruptive technologies, they found that "firms lose their position of industry leadership… [when]…they listen too carefully to their customers" (p.198). They argue a firm's exclusive focus on its customers' needs yields myopic behaviors that impede the development of innovative product solutions. Such arguments have been carried forth by Hamel and Prahalad (1991) as well as others (Narver and Slater 1990; Zhou et al. 2005) that contend "listening too closely to your customers" will lead to misguided product development efforts and discourage a firm from thinking outside the box. For instance, in Zhou et al.'s (2005) study of durable and non-durable consumer products in China, they found that a consumer driven focus negatively influences a firm's ability to innovate.

In response to these limitations in the market orientation approach, some marketing researchers have advocated an "organizational learning orientation" (Hurley and Hult 1998; Narver et al. 2004; Slater and Narver 1995; Zhou et al. 2005). Slater and Narver (1995) contend that firms need to develop a greater "openness" to "learning partners" that extend well beyond the needs and preferences of consumers. The learning organization needs to be open to "…other learning sources, such as suppliers, businesses in different industries, consultants…[in which]... the concept of "market" should be broadened to encompass all sources of relevant knowledge" (Slater and Narver 1995, 68). Such openness implicitly recognizes that the development of products is based on an innovative process in which the development of products are not limited to the technological confines of a firm, but such developments are built upon the technological achievements of connected others (e.g. Brown and Eisenhardt 1995; Scotchmer 1991). Such openness is particularly important in situations when consumers cannot fully comprehend the commercial value of emerging technologies (e.g. Atuahene-Gima and Ko 2001; Narver et al., 2004; Slater and Narver 1995; Zhou et al. 2005). This is because Slater and Narver (1995) argue that by gaining access to the experiences of technological partners, the learning organization is better positioned to assess the commercial value of technical advances and thus enabling the firm to develop products that consumers did not anticipate in needing (see also Hamel and Prahalad 1991).

Yet, although Slater and Narvers' (1995) organizational learning orientation has been an important extension to the market orientation concept (Hurley and Hult 1998; Zhou et al. 2005), the causal factors and processes that impact this "openness" is not well understood (Hurley and Halt 1998; Narver et al. 2004; Slater and Narver 1995). This is because a firm's openness to new ideas has been largely attributed to an "inside-out" learning process in which the focus has been on the "generation" and "dissemination" of market intelligence (e.g. Atuahene-Gima and Ko 2001; Hamel and Prahalad 1991; Jaworski and Kohli 1993; Narver et al. 2004; Slater and Narver 1995; Zhou et al. 2005). For instance, the "generation" of market intelligence stems from an "entrepreneurial" mindset that involves creating new product-markets through a firm's internal product experimentation and risk taking efforts (Slater and Narver 1995). Furthermore, given this internal generation of market intelligence, various marketing research has emphasized that the diffusion of information is another important aspect of a firm's "inside-out" learning process because it promotes the sharing and coordination of inter-departmental product development activities (e.g. Benedetto 1999; Dougherty 1992; Han et al. 1998; Jaworski and Kohli 1993; March and Stock 2003; Narver and Slater 1990).

Yet, as the creation of products involves sourcing technologies that are not held by any one firm (Powell *et al.* 1996; Rothaermel 2001; Rothaermel and Deeds 2004), this "inside-out" learning processes does not sufficiently account for a firm's "openness" to such "outside" influences. Namely, a firm's ability to assimilate and commercialize external ideas has not been a primary factor to "inside-out" learning explanations (e.g. Hurley and Hult 1998). As a result, in drawing on the "openness" ascribed by Slater and Narver (1995), there has been efforts to incorporate "outside-in" learning processes within an organizational learning approach (e.g. Hurley and Hult 1998; Zhou et al. 2005).With such an "outside in" learning process, the development of products stems from a firm's ability to internalize the external experiences of its "learning partners". Hurley and Hult (1998) describe "being oriented towards learning [also] indicates an appreciation for and desire to assimilate new ideas" (p. 44). Such openness has been supported in the new product development studies of Brown and Eisenhardt (1995) and Wind and Mahajan's (1997) who found that a firm's development of products is increasingly driven by its ability to adopt "outside" technological influences. However, in spite of this greater recognition that external or "outside" technologies can influence a firm's "internal" product development efforts, their remains limited understanding in marketing research of the factors that impact a firm's ability to assimilate such external influences (e.g. Narver et al. 2004).

Nevertheless, Cohen and Levinthal's (1989 and 1990) concept of absorptive capacity offers one approach to understanding this "outside-in" learning process. Absorptive capacity is based on a path dependent property in which a firm's ability to internalize external experiences is a self-reinforcing function of its past experiences (Cohen and Levinthal 1990). Specifically, by drawing on research on memory development, Cohen and Levinthal (1990) argue that firms with a greater depth and diversity of experiences are not only better able to internalize external experiences, but this internalization subsequently increases a firm's memory and thus experience to assimilate and commercialize external information in the next period (see also Bosch et al. 1999; Lane et al. 2006; Zahra and George 2002). As a consequence of this path dependent property, a distinctive feature of this absorptive capacity concept is that a firm's experiences positively influence its ability to innovate (e.g. Bosch et al. 1999; Lane et al. 2006; Zahra and George 2002). For instance, in the biotechnology industry, Nerkar and Roberts (2004) and Nixon and Woos' (2003)

studies respectively found that a biotechnology firm's cumulative and diversity of experiences positively influence a firm's product innovation.

Although the concept of absorptive capacity appeals to the openness of an "outside-in" learning process, this concept however faces two conceptual challenges. First, although a firm's experiences are generally recognized by absorptive capacity researchers to have a positive influence on its product innovation (e.g. Bosch et al. 1999; Lane et al. 2006; Zahra and George 2002), cognitive researchers find that a firm's cumulative experiences can however yield a selective interpretation of its outside environment. Such an interpretative bias can result in "competency trap" or "dominant logic" behaviors that reduce a firm's ability to assimilate outside innovations (Levinthal and March 1993; Prahalad and Bettis 1986; Tripsas and Gavetti 2000). Furthermore, although a greater diversity of experiences can overcome such dominant logic behaviors (Bosch et al. 1999; Cohen and Levinthal 1990; Lane et al. 2006; Zahra and George 2002), various marketing studies have found that increasing a firm's diversity of internal experiences limits a firm's product development process. This is because diversity places greater demands in coordinating inter-departmental activities (e.g. Dougherty 1992; Jaworski and Kohli 1993; Narver and Slater 1990). Second, as the concept of absorptive capacity is a firm level construct, researchers tend to focus on organizational experiences and mechanisms that promote the assimilation of externally relevant information (e.g. Lane et al. 2006; Todorova and Durisin 2007; Zahra and George 2002). This firm level focus is thereby emphasized at the expense of external or "outside" partnership experiences. Yet various studies have shown that alliance partnerships can positively influence a firm's product development process (Ng et al. 2006; Rothaermel 2001; Rothaermel and Deeds 2004). With the possible exception of Hess and Rothaermel (2011) and Rothaermel and Hess (2007)[1], the relationship between a firm's absorptive capacity and its ability to gain access to such "outside" experiences remains largely underdeveloped in mainstream absorptive capacity research.

Hence, to explain a firm's product development process, a conceptual framework that examines a firm's "outside in" learning process is developed to address these two challenges. Specifically, although increases in a firm's experiences have been found to positively influence its ability to assimilate external ideas, Lane et al. (2006) argue that with the exception of few scholars, few have challenged "the continued benefits of such expansion" (p. 847 see also Lei and Hitt 1995; Vermeulen and Barkema 2002). For instance, Vermeulen and Barkema (2002) argue that too rapid an expansion in a firm's knowledge may not provide enough time to absorb the new knowledge. Furthermore, Lei and Hitt (1995) argue that expansion in knowledge through acquisitions may affect absorptive capacity negatively because of a firm's failure to develop its own absorptive capacity. Although, both studies underscore the limits with expanding a firm's experiences, a firm's cumulative experiences are however also shaped by its unique interpretation of external events. Furthermore, the coordinative challenges associated with expansions in firm's diversity of knowledge can also limit a firm's absorptive capacity. Hence, the conceptual challenge facing absorptive capacity research is determining the nature of those constraints that are associated with these expansions in a firm's experiences. Another conceptual challenge facing absorptive capacity research is that since the development of products depends on sourcing technologies and resources from alliances partners, a firm's cumulative and diverse experiences not

[1] In these studies, their primary focus is not on the product development process. Their focus is on drawing on a dynamic capability approach to the absorptive capacity concept in which flexibility and responsiveness to changing environments were emphasized.

only need to account for potential constraints in their ability to assimilate external experiences, but these firm level experiences need to also account for the product benefits of their alliance partners. Yet, with the possible exception of Hess and Rothaermel (2011) and Rothaermel and Hess (2007), the role of a firm's experiences and their associated constraints in assimilating the experiences of its learning partners has not been a subject of focus of absorptive capacity studies. By addressing these two challenges, a conceptual framework is developed to extend the concept of absorptive capacity in two ways. First, this framework proposes and empirically shows that increasing a firm's cumulative and diverse experiences can eventually diminish a firm's ability to introduce products to the market. As a result, unlike the commonly accepted wisdom in absorptive capacity research (e.g. Bosch et al. 1999; Zahra and George 2002), continued investments in a firm's absorptive capacity are not optimal to sustaining a firm's competitive advantage. Second, the firm-level focus of the absorptive capacity concept is extended to account for the moderating role of alliances. A firm's cumulative and diverse experiences are not only subject to diminishing effects, but the nature of such experiences can distinctly moderate the product benefits of its alliance partners. To empirically examine these extensions, the biotechnology industry was used to examine the relationship between a biotechnology firm's absorptive capacity, alliances and their moderating effects on its product market introductions.

Conceptual Model

In developing this study's conceptual framework, its unit of analysis and definitions are first outlined. The innovating firm is the subject of focus in this study (e.g. Cohen and Levinthal 1990). Although there are various characterizations, an innovative firm is not strictly defined by a firm that introduces new and breakthrough products (e.g. Danneels and Kleinschmidt 2001). That is, in drawing on an organizational learning orientation, the innovative firm is defined by a learning process (e.g. Hurley and Hult 1998; Slater and Narver 1995; Rindfleisch and Moorman 2003) that involves the "generation" of new knowledge (see also Jaworski and Kohli 1993) from a firm's "openness" to new experiences. Such a characterization is not only consistent with Cohen and Levinthals' (1989 and 1990) concept of absorptive capacity, but it is also consistent with Slater and Narvers' (1995) organizational learning orientation. Slater and Narver (1995) argue innovation and learning are intimately related because innovation involves the "development of new knowledge or insights that have the potential to influence behavior" (p. 63).

Specifically, this "potential" is reflected by a firm's product performance or product introductions. Namely, a firm's product performance is the outcome of a firm's innovation process in which product introductions reflect underlying changes in a firm's knowledge (see also Hurley and Hult 1998). A firm's product performance is defined by the number of products introduced to the market (Nerkar and Roberts 2004; Tsai 2001; Wuyts et al. 2004; Zaheer and Bell 2005; Zahra and George 2002). As a result, products are innovative not necessarily because they constitute a breakthrough product (e.g. Danneels and Kleinschmidt 2001), but because they stem from an innovative process that involves changes in a firm's experiences from an openness to external ideas. Such a characterization of product performance follows the logic of an organizational learning orientation (e.g. Cohen and Levinthal 1990; Slater and Narver 1995).

Absorptive Capacity

To elaborate on this innovative process, Hurley and Hult (1998) and March and Stock (2003) argue Cohen and Levinthals' (1990) concept of absorptive capacity is suited to examining this aspect of a firm's learning process. Absorptive capacity refers to a firm's "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990, 128). This concept explicitly recognizes that the innovation process is built on a firm's ability to "borrow" the technical achievements of others (e.g. Cohen and Levinthal 1990; Scotchmer 1991). For instance, Cohen and Levinthal (1990) note "outside sources of knowledge are often critical to the innovation process… [in which]…March and Simon (1958, 188) suggested most innovations result from borrowing rather than invention" (p. 128). Cohen and Levinthal (1990) argue that this "borrowing" is highly dependent on a firm's experiences. This dependence on a firm's experiences stems from research on memory development in which Cohen and Levinthal (1990) describe, "research on memory development suggests that accumulated prior knowledge increases both the ability to put new knowledge into memory, what we would refer to as the acquisition of knowledge, and the ability to recall and use it" (Cohen and Levinthal 1990, 129).

Cohen and Levinthal (1990) argue that increasing a firm's experiences not only increases memory and thus absorptive capacity, but the greater ability to utilize the assimilated experiences subsequently increases a firm's ability to assimilate and commercialize external information in the next period (e.g. Bosch et al. 1999; Lane et al. 2006; Zahra and George 2002). Hence, due to such path dependence, a firm's ability to assimilate and commercialize external information is a "self-reinforcing" function of its past experiences (Bosch et al. 1999; Cohen and Levinthal 1989 and 1990; Lane et al. 2006; Zahra and George 2002).

Due to this path dependent property[2], various researchers have subsequently argued that a firm's cumulative knowledge positively influences its ability to introduce products to the market (e.g. Bosch et al. 1999; Lane et al. 2006; March and Stock 2003; Nerkar and Roberts 2004; Nicholls-Nixon and Woo 2003; Zahra and George 2002). Namely, as a firm's cumulative experiences increase its absorptive capacity to commercialize products from emerging technologies, the knowledge acquired from the development of such products increases a firm's ability to put more knowledge into memory. This increases a firm's ability to further assimilate technologies into the development of products in the next period. Hence, as a firm accumulates increasing experiences, it becomes increasingly "open" to new technological advances and thus increasing its ability to develop new products. In this fashion, continued expansions in a firm's cumulative experiences are a source of sustainable competitive advantage because it positively influences a firm's ability to bring products to market. For instance, studies by Nerkar and Roberts (2004), Nicholls-Nixon and Woo (2003), Sorenson and Stuart (2000), and Tsai (2001) find that increases in a firm's cumulative experiences positively influences a firm's product innovations.

Similarly, a firm's diverse knowledge is also positively related to a firm's product innovations (Ahuja and Katila 2001; Isobe et al. 2000; Lane et al. 2006; Ng 2007). That is, since prior learn-

[2] Readers should note that as this path dependent property is generally recognized by most absorptive capacity researchers, the focus of this study is not on the examination of this property but on examining the "effects" or consequences of this property on a firm's product development process.

ing facilitates new learning, a firm with diverse knowledge experiences increases its ability to relate to a greater breadth of external experiences (Cohen and Levinthal 1990). As Cohen and Levinthal (1990) describe, diverse knowledge experiences provide "…a more robust basis for learning because it increases the prospect that incoming information will relate to what is already known" (p.131). With such diversity, a firm is not only able to assimilate a broader set of experiences, but its assimilation increases a firm's "combinative abilities" to seek new resource linkages and configurations (Bosch et al. 1999; Cohen and Levinthal 1990; Zahra and George 2002). Such combinative abilities are important to the product development process because product innovations are driven by a process of novel resource and experience combinations (March and Stock 2003; Schumpeter 1934).

As a result, the concept of absorptive capacity suggests that increasing expansions in a firm's cumulative and diverse knowledge yield an increasing ability to introduce products to the market. This follows Cohen and Levinthals' (1989) earlier paper in which they argue a firm's absorptive capacity is a source of sustainable competitive advantage because increasing a firm's past – cumulative and diverse- experiences increasingly lowers the cost of assimilating and commercializing external information. By lowering the cost of assimilating this external information, it increases a firm's ability to develop new products (see also Bosch et al. 1999; Zahra and George 2002). Yet, in spite of this positive relationship, Simon (1957) and Cyert and March (1963) have long argued that firms are subject to basic cognitive limits in their ability to mentally process and coordinate externally assimilated information. Such cognitive limits suggest that the positive effects of a firm's absorptive capacity can be subject to diminishing returns.

Diminishing Effects to a Firm's Absorptive Capacity

Cumulative knowledge. Cognitive research suggests that firms with greater cumulative experiences are subject to systematic biases in their *interpretation* of external information (Daft and Weick 1984; Prahalad and Bettis 1986; Tripsas and Gavetti 2000; Walsh 1995; Weick 1969; Zahra and Chaples 1993). A firm with cumulative experiences attach increasing significance to its prior beliefs and thus interprets its information environment in ways consistent with these prior beliefs (e.g. Prahalad and Bettis 1986; Tripsas and Gavetti 2000; Walsh 1995). This selective interpretation has been widely attributed to a "confirmation bias" (Nickerson 1998; Russo and Schoemaker 1992; Walsh 1995). A confirmation bias is a robust feature of human judgment and has been empirically observed in a variety of management and organizational settings (e.g. Nickerson 1998; Russo and Schoemaker 1992). A confirmation bias reflects an affirmation of an individual's cumulative experiences in which an individual selectively interprets external information that is consistent with her established beliefs. For example, in the socio-cognitive development of Cochlear implant technology, Garud and Rappa (1994) show that an individual's cumulative experiences can increasingly "bracket" or limit an individual's interpretation of external information (see also Daft and Weick 1984; Weick 1969). They describe, "data inconsistent with an individual's evaluation routines are either ignored or appear as noise.... Given bounds to rationality, this bracketing of perception occurs because individuals may be more interested in confirming their beliefs than in actively trying to disprove them (Weick 1969)" (p. 347).

Such a confirmation bias can yield "dominant logic" or "competency trap" behaviors (Prahalad and Bettis 1986; Slater and Narver 1995) in which a firm reinforces the assimilation of infor-

mation and activities that reproduce past beliefs of success. Such behaviors inhibit a firm's ability to explore new product market opportunities (Prahalad and Bettis 1986; Tripsas and Gavetti 2000). Thus, as increases in a firm's cumulative experiences yield a confirmation bias, the resulting dominant logic diminishes a firm's ability to bring products to market.

A firm's cumulative experiences not only promotes this form of confirmation bias, but such a bias can subsequently yield the development of "organizational routines" (Cohen and Bacdayan 1994; Levitt and March 1988; Nelson and Winter 1982). Organizational routines are "patterned sequences of learning behaviors" involving "established patterns of organizational action" (Cohen and Bacdayan 1994, 555). Search routines are instrumental in economizing a firm's rationality because they confine a firm's search to information that is related to its past experiences (Levinthal and March 1993; Levitt and March 1988; Nerkar and Roberts 2004). Search routines are thereby mutually related to a firm's confirmation bias. That is, as a firm's cumulative knowledge yields the onset of a confirmation bias; such a bias promotes "search routines" in seeking information that reinforces a firm's prior experiences (Nerkar and Roberts 2004). These search routines deepen a firm's past experiences (Levitt and March 1988) which positively influences a firm's absorptive capacity to assimilate information that is consistent with these experiences. This yields a pattern of learning that not only reinforces the development and establishment of such search routines. But these routines subsequently generate myopic behaviors that blind the firm to external technological advances (e.g. Levitt and March 1988). As result, by increasing a firm's cumulative experiences, a firm's confirmation bias yields search routines that reduce a firm's absorptive capacity to assimilate external technological advances and thus diminishing a firm's ability to bring products to market. Such diminishing effects can thus also yield the "dominant logic" behaviors described by Slater and Narver (1995) and Prahalad and Bettis (1986).

Biotechnology firms are particularly vulnerable to such diminishing effects. Due to the high costs associated with the product development process ($800 million / product) (DiMasi 2001; DiMasi et al. 2003), there are strong incentives to leverage a biotechnology firm's cumulative experiences. By leveraging a biotechnology firm's cumulative experiences, the biotechnology firm is vulnerable to a confirmation bias. Such a bias promotes the development of search routines that drive out a biotechnology firm's ability to assimilate more distant biotechnological discoveries. This follows Nerkar and Roberts' (2004) study of the biotechnology industry in which they argue biotechnology firms tend to not only leverage their technical experiences, but in doing so favor a search of technologies that are in close proximity to their established expertise. This is also consistent with Rawlins' (2004) assessment of biotechnology companies where he argues biotechnology companies tend to "focus on improving approaches that have been clinically proven and financially successful, and [have] a disincentive to develop products for unmet medical needs" (p. 360). Yet, as the development of biotechnology products rests on a firm's ability to commercialize emerging advances in areas such as recombinant DNA or "rDNA", protein engineering, monoclonal antibody or "Mabs" technology (Liebeskind et al. 1996; Rader 2005), such myopic behaviors can thereby diminish a biotechnology firm's absorptive capacity in capitalizing on these advances. Hence, even though absorptive capacity researchers contend that a firm's cumulative experiences positively influences the development of product innovations (Bosch et al. 1999; Lane et al. 2006; March and Stock 2003; Nicholls-Nixon and Woo 2003), a firm's cumulative experiences can also yield a confirmation bias that promotes the development

of dominant logic behaviors that diminish the product performance benefits of a biotechnology firm's absorptive capacity.

Hypothesis 1a: Increasing a biotechnology firm's absorptive capacity – cumulative knowledge – exhibits a positive yet diminishing effect on its product performance.

Diverse knowledge. A firm's diverse knowledge is also subject to a diminishing return effect. However, unlike a firm's cumulative experiences, this diminishing effect is rooted in a "serial reproduction loss" problem (Markides 1995; Williamson 1967). A "serial reproduction loss" problem refers to the notion that as information is transmitted across increasingly diversified or specialized units, the quality of the transmitted information deteriorates (Markides 1995; Williamson 1967). This deterioration arises because as the assimilated information is transmitted across diversified sub units, the transmitted information becomes increasingly distorted by the experiences and perceptions of that unit (see also Brown and Eisenhardt 1995; Dougherty 1992). For instance, in Dougherty's (1992) study, she found departments or subunits of a firm were trapped in "departmental thought worlds" in which each subunit filtered information from their particular areas of specialization, while ignoring information that is not relevant to their tasks.
With continued expansions in a firm's diversity of experiences, this serial reproduction loss problem diminishes a firm's absorptive capacity because degradations in information quality reduce a firm's "coordinative capabilities" (Bosch et al. 1999). Bosch et al. (1999) describe that "coordination capabilities enhance knowledge absorption through relations between members of a group. They refer to lateral ways of coordination" (p. 556) that involve job rotations, intergroup communication activities, and cross functional interfaces. Such coordinative capabilities require that members from each coordinating unit have "overlapping" experiences with other members (Cohen and Levinthal 1990; Slater and Narver 1995). Yet, since the "serial reproduction loss problem" reduces the quality of the assimilated information, this reduces a firm ability to coordinate novel linkages amongst members of "overlapping" (Cohen and Levinthal 1990) subunits and thus mitigates the development of products. For instance, Han et al. (1998) describe, "if personnel in different departments do not open up to one another, they are more likely to conform to their routine mode of problem solving and less likely to be creative and take risks" (p. 34). This suggests that with increasing diversity, problems associated with a firm's serial reproduction loss problem will also increase and thus diminish a firm's coordinative capabilities. Hence, due to this serial reproduction loss problem, continued expansions in a firm's diversity will eventually overwhelm the benefits of a firm's absorptive capacity and thus diminish a firm's ability to bringing products to the market.

Biotechnology firms are particularly vulnerable to such diminishing effects. Studies find that the commercialization of biotechnology products depends on a firm's ability to combine knowledge from individuals in different units (Drew 2000; Hood 2003; Nerkar and Roberts 2004; Rader 2005). For instance, the development of new biotechnology products, such as the development of therapeutic drugs and / or agricultural / life science bio-engineered crops, draw on a variety of overlapping disciplines or specialty areas. This not only involves recombinant DNA or "rDNA", protein engineering, monoclonal antibody or "Mabs" technologies (Liebeskind et al. 1996; Rader 2005), but also advances in computing sciences, molecular biology, applied physics, protein chemistry, applied statistics, pharmacology and toxicology (Hood 2003). As each of these areas are based on distinct yet related disciplines (Drew 2000; Hood 2003), individuals in subunits that

reflect each of these respective areas will assimilate information that is relevant to their functional experiences (e.g. Dougherty 1992). Yet, as external information is assimilated through a firm's various subunits (Cohen and Levinthal 1990), a firm with an increasingly diverse array of such specialized expertise is increasingly vulnerable to the serial reproduction loss problem. This serial reproduction loss problem reduces the quality of the externally assimilated information and thus reduces a firm's ability to discover novel linkages among its diverse areas of specialized expertise. Hence, despite the assimilative benefits of diversity (Bosch et al. 1999; Cohen and Levinthal 1990), excessive diversity can yield a serial reproduction loss problem that diminishes a biotechnology firm's absorptive capacity in bringing products to market.

Hypothesis 1b: With increasing diversity, a biotechnology firm's absorptive capacity - knowledge diversity – exhibits a positive yet diminishing effect on its product performance.

Inter-Organizational Learning: Absorptive capacity and Strategic Alliances

A firm's product performance also depends on an "openness" to its "learning partnerships" (Rindfleisch and Moorman 2001 and 2003; Slater and Narver 1995). In the biotechnology industry, such "openness" involves forming strategic alliances (Chan et al. 1997; Powell et al. 1996; Rothaermel and Deeds 2004). Strategic alliances positively influence the commercialization of biotechnology products because biotechnology products are based on multiple technologies that are not held by any single firm (Chan et al. 1997; Deeds and Hill 1996; Powell et al. 1996; Rothaermel 2001). In fact, various empirical studies have found that biotechnology alliances involving licensing, R&D, commercializing, marketing and distribution alliances positively influence a biotechnology firm's product performance. This is because these alliances provide an assortment of resources and experiences that complement a firm's internal learning (Ng et al. 2006; Nerkar and Roberts 2004; Powell et al. 1996; Rothaermel, 2001; Rothaermel and Deeds 2004). In particular, Powell et al. (1996) argue alliances can complement or positively moderate a biotechnology firm's absorptive capacity because alliances provide a biotechnology firm access to external knowledge, while at the same time deepen a biotechnology firm's ability to assimilate and develop new innovations.

Such a positive moderating effect however requires greater scrutiny (see also Lane et al. 2006). Since a biotechnology firm's cumulated knowledge yields a confirmation bias, such a bias yields search routines that select alliances partners with similar experiences. This is consistent with Mowery et al.'s (1996) study of hi-technology industries where they found inter-firm knowledge transfers are more frequent with partners who share similar technological capabilities. This is also consistent with Lane and Lubatkins' (1998) study of student and instructor relationships where they found the assimilation and transfer of information are influenced by a common body of scientific knowledge. As a result, this suggests that as a firm's cumulative experiences yield a confirmation bias, a firm's search routines will favor exchanges with "redundant" partners (see also Rindfleisch and Moorman 2003). By assimilating such redundant experiences, a biotechnology firm is subject to "network myopic" (Gargiulo and Benassi 2000) behaviors whereby a firm's search for redundant alliance partners further deepens its cumulative experiences. This suggests that a biotechnology firm's cumulative experiences reduce a firm's ability to fully leverage the varied experiences of its network. As a result, despite the product benefits of alliances, a firm's cumulative experiences can have a negative interacting effect to the product benefits of its alliances.

Hypothesis 2a: the moderating effect of a biotechnology firm's absorptive capacity - cumulative knowledge - on its alliances is negatively related to its product performance.

On the other hand and consistent with Powell et al. (1996), a biotechnology firm's diverse knowledge can complement or positively moderate the product benefits of its alliances. Diverse knowledge experiences increase the likelihood that the biotechnology firm possesses technologies and experiences that complement the expertise of its alliance partners. As the innovation process stems from a recombination of diverse experiences and resources (Nerkar and Roberts 2004; Nichols-Nixon and Woo 2003; Schumpeter 1934), a firm's diverse knowledge increases the potential to form partnerships that more fully exploit the varied experiences of its network. This assimilation increases a firm's combinative abilities to seek new resource combinations and thus increases a firm's ability to develop new products. As a result, unlike a firm's cumulative experiences, a firm's diversity of experiences positively moderates the product benefits of its alliances.

Hypothesis 2b: The moderating effect of a biotechnology firm's absorptive capacity - diverse knowledge- on its alliances is positively related to its product performance.

Method

Data and Sample

To empirically examine this study's hypotheses, the biotechnology industry was chosen for two reasons. First, researchers find the development of biotechnology products often depends on a biotechnology firm's ability to assimilate basic advances in varied yet related disciplinary areas involving recombinant DNA or "rDNA", protein engineering and monoclonal antibody or "Mabs" technology (Liebeskind et al. 1996), computing sciences, molecular biology, applied physics, protein chemistry, applied statistics, pharmacology and toxicology (Hood 2003). Such advances in basic research have led to the rapid growth of human therapeutic and agricultural / life science based products and services (Liebeskind et al. 1996; Ng et al. 2006; Rader 2005). The assimilation of such basic advances in biotechnology and its subsequent commercialization is thereby suited to examining this study's extensions to the absorptive capacity concept. Second, since a biotechnology firm's product development process often requires forming multiple alliance partnerships (Chan et al. 1997; Deeds and Hill 1996; Liebeskind et al. 1996; Rothaermel and Deeds 2004), alliances underscore that the locus of learning in the biotechnology industry is not only influenced by a firm's absorptive capacity but it is also influenced by a firm's learning partners (e.g. Powell et al. 1996; Slater and Narver 1995). This yields a learning process that reflects the greater "openness" called for by Slater and Narver (1995).

Based on these motivations, a sample of 369 public biotechnology firms (Deeds and Hill 1996; George et al. 2002; Powell et al. 1996) was drawn from the 2004 "BioScan" database (American Health Consultants 2004). The BioScan database has been recognized as one of the most comprehensive and reliable databases in the biotechnology industry (Deeds and Hill 1996; Powell et al. 1996; Rothaermel 2001; Rothaermel and Deeds 2004) and has been used by a variety of alliance researchers (e.g. Deeds and Hill 1996; George et al. 2002; Powell et al. 1996; Rothaermel

2001; Rothaermel and Deeds 2004). As various industry analysts have argued that the distinction between biotechnology and pharmaceutical firms has become increasingly amorphous (Hopewell 2003; Rader 2005)[3], the BioScan database includes both life science and pharmaceutical companies. This study's data sample includes both types of companies (Rader 2005)[4].

Measures

Dependent variable. As product introductions reflect the outcome of a firm's innovation process, a biotechnology firm's product performance is measured by the cumulative number of commercialized biotechnology products or product introductions, since its founding. A similar definition of firm performance has also been used in prior product studies (Deeds and Hill 1996; Nerkar and Roberts 2004; Rothaermel 2001; Rothaermel and Deeds 2004) and is consistent with one of the absorptive capacity (output) measures (i.e. new product announcements) proposed by Zahra and George (2002).

Independent variables (absorptive capacity). Although the concept of absorptive capacity is well developed in management research, empirical measures for this concept remain a subject of much debate (Lane et al. 2006). For instance, although a firm's absorptive capacity has been commonly measured by a firm's R&D intensity (i.e. ratio of R&D expenditures to sales) (e.g. Cohen and Levinthal 1989 and 1990), the validity of this measure has been questioned (Lane et al., 2006). Namely, R&D intensity is often measured as a "stock of relevant knowledge" (Lane et al. 2006) to which it serves as an input to a firm's absorptive capacity. Yet, absorptive capacity is a multi-dimensional concept that consists of "an organizational learning ability" (Lane et al. 2006, 841). Since the objective of this study is to explain a firm's product development process through an organizational learning orientation (Narver and Slater 1990), R&D intensity is not suitable for this learning focus. In that, Mowery et al. (1996) argue that R&D intensity, as a stock of knowledge, does not account for a firm's learning process. Furthermore, as this organizational learning orientation involves an openness to alliances partners, Mowery et al. (1996) also found that R&D intensity was not a good predictor of inter-organizational learning.

From an econometric standpoint, the use of R&D intensity is problematic because it introduces a simultaneous causality problem or simultaneous bias (Wooldridge 2003; Stock and Watson 2007). The use of R&D intensity (R&D expenditures / sales) or even measures proposed by Zahra and George (2002), such as "amount of R&D investment" (Zahra and George 2002, 199) or "years of experience in the R&D department" (p. 199) are simultaneously related to the dependent variable, product introduction. This is because since product introductions are defined by the number of commercialized products, commercialized product are directly related to sales (Mowery et al. 1996), R&D expenditures and years experiences in R&D (Zahra and George 2002). With this simultaneous causality problem, measures based on R &D intensity or those proposed by Zahra and George (2002) would be correlated with the error term and thus resulting

[3] This is because pharmaceutical companies are no longer restricted to analytical chemistry in the development of drugs. Drug development has turned to genetic engineering to yield specific therapeutic properties (Hopewell, 2003; see also Rader, 2005).

[4] This study draws on an industry definition of the Biopharmaceutical firm that "includes all/everything from biotech like (smaller, entrepreneurial, R&D intensive) pharmaceutical and life science companies as being biopharmaceutical" (Rader, 2005, p 61). However, to avoid any unnecessary confusion with this term, we use biotechnology to include pharmaceutical and life science companies.

in a biased estimate (e.g. Wooldridge 2003; Stock and Watson 2007). One solution to this simultaneous causality problem is to choose proxies that exhibit a less direct relationship with the product introduction variable (e.g. Stock and Watson 2007; Wooldridge 2003). Specifically, the three following measures – age, employees, and diversity, were chosen as proxies to the absorptive capacity concept because relative to measures, such as R&D intensity (Cohen and Levinthal 1989 and 1990) and those measures proposed by Zahra and George (2002), these proxies not only have a less direct relationship to the product introduction variable, but they also serve to capture the learning aspects of the absorptive capacity concept (Lane et al. 2006).

Cumulative knowledge. Namely, to capture the learning capability aspects of the absorptive capacity concept, researchers have suggested a firm's "age" as a proxy measure for absorptive capacity (Hurley and Hult 1998; Lane et al. 2006; Rao and Drazin 2002; Sorenson and Stuart 2000). Studies have suggested that a firm's age can impact the extent to which a firm is receptive to new ideas (Hurley and Hult 1998; Lane et al. 2006; Sorensen and Stuart, 2000). In particular, Lane et al. (2006) argue that "proxies such as age and size have been used to argue that older and larger firms have higher absorptive capacity because they are likely to have accumulated knowledge and developed routines and processes [that] facilitate assimilation and innovation" (p. 944). Age is thus used to capture the routine aspects of a firm's cumulative learning. A biotechnology firm's Age is computed as the difference between the period of this data sampling (2004) and its founding date. As size is also another measure of cumulative knowledge (Lane et al 2006; Sorensen and Stuart, 2000), the number of employees is used as another measure because employees are also engaged in a firm's learning process (Graves and Langowitz 1993).

Diversity. Since the development of biotechnology products often draws on variety of specialized expertise (Hood 2003; Powell et al. 1996), knowledge diversity is measured by the cumulative number of unique subfields in which the firm has participated in. BioScan (2004) provides a description of the distinct areas of research application and focus pursued by each company. Diversity is measured as a count of a firm's total number of distinct technological and/or research areas of specialization (Rothaermel and Deeds 2004). Rothaermel and Deeds (2004) had used this measure for their study of the biotechnology industry. This diversity measure has also been used by Nicholls-Nixon and Woo (2003) and is consistent with Hurley and Hult (1998) who argue that a diversity of specialized skills can impact a firm's innovation process.

Strategic alliances. Alliance is a count of the cumulative alliances formed by the firm since its founding (Ahuja 2000). Alliance is the aggregation of Licensing, Research and Development (R&D), Marketing, Manufacturing, and Distribution agreements. The aggregation of these alliances is commonly used to measure a firm's connectedness in the biotechnology industry (Chan et al. 1997; Deeds and Hill 1996; Powell et al. 1996). Specifically, Slater and Narver (1995) describe the learning organization needs to be open to "…other learning sources, such as suppliers, businesses in different industries, consultants…[in which]... the concept of "market" should be broadened to encompass all sources of relevant knowledge" (p. 68). Hence, to capture this openness to learning partners, the aggregation of these alliances types was used.

Control Variables

To control for other factors that impact a firm's product introductions, a firm's Mergers and Acquisitions (M&A) was used. Since M&A are motivated to exploit scope economies through product line extensions, this control is included. Moreover, since larger firms have greater financial resources, they are more likely to undertake M&A. Such a measure is used to control for firm size effects that are separate from the age, employee and diversity measures of absorptive capacity. A firm's M&A is computed as the difference in the cumulative number of biotechnology mergers less divestitures, since its founding. Moreover, to account for any institutional differences, the site or location of the firm, noted as Location, is coded as a dummy variable (0= U.S. - based, 1= non-US based) (e.g., Rothaermel and Deeds 2004). The number of Subsidiaries held by a firm is included because they provide entrance into new product markets (Rothaermel and Deeds 2004). Lastly, as institutional investors provide sources of funding in bringing products to markets, the number of institutional shareholders, Investors (i.e., investors from major banks, fund agencies), is included.

Estimation Procedure

As the dependent variable, product performance, is count data, both negative binomial and Poisson regressions using Maximum Likelihood Estimation (MLE) methods were conducted. However, in the Poisson estimations, the Likelihood ratio test statistics of delta were all significant ($p < 0.01$). This indicates the presence of over dispersion (table 2) which violates the Poisson distributional assumption of mean-variance equivalence. Such a violation overstates the significance of the estimated variables (Long and Freese 2006). As a result, although the Poisson estimation results were generally consistent with the negative binomial estimations, only the negative binomial estimation results are reported.

When examining the interaction effects (hypotheses 2a and 2b), the main effects of a firm's absorptive capacity and alliance variables were mean-centered (i.e., observations less their mean values) to minimize problems of multi-collinearity (Aiken and West 1991). Interactions are subsequently based on these mean-centered values (Aiken and West 1991). Furthermore, Cortina (1993) contends that if the main effects of an interaction are highly correlated, significant estimates on the interaction term can be "artifactual". That is, if two main components X (i.e., absorptive capacity) and Z (i.e. alliances) are highly related (i.e., $\rho_{x,y} = 1$), then "a statistically significant interaction term is significant because of a nonlinear multiplicative effect (i.e., curvilinearity effect) and not because of a linear multiplicative effect (interaction effect)" (Cortina 1993, 917). A solution is to control for possible curvilinearity effects - before the interaction term - such that it rules out the alternative explanation that interactive effects are attributed to curvilinearity effects (Cortina1993). Since the concepts of absorptive capacity and alliances are theoretically and empirically correlated (see table 1), estimations of these interactions require controlling for such curvilinearity effects. The quadratic terms for the main effect variables are included to control for such effects. The inclusion of these additional variables is also theoretically consistent with hypothesis 1a and 1b. Moreover, as the estimated models consist of various interactions, the models were assessed for multi-collinearity. Multi-collinearity is moderate to strong when the Variance Inflation Factor (VIF) exceeds 10. Based on all the described variables, the mean VIF is 4.39. Model estimations were conducted with the Stata 9.1 econometrics software.

Results

The descriptive statistics for all co-variants and their correlations are shown in Table 1. The marginal effects for each variable in the negative binomial estimations are shown in Table 2.
From Table 2, Model 1 shows that with the exception of investors, all control variables are significant. The location dummy variable is negative which indicates U.S. based firms market fewer products than non U.S. based firms. The subsidiary coefficient is positive as expected. This is consistent with Rothaermel and Deeds' (2004) findings. The number of M&A is positive and significant, as expected.

Table 1. Descriptive Statistics and Correlations

Variables	MEAN	ST. DEV	1	2	3	4	5	6	7	8	9
1 Products	4.310	7.830	1.000								
2 Location	0.651	0.477	-0.101	1.000							
3 Investors	1.890	3.430	-0.113	0.143	1.000						
4 Subsidiaries	3.150	13.630	0.344	-0.032	-0.083	1.000					
5 Employees	3817.500	14362.900	0.439	-0.080	-0.129	0.494	1.000				
6 Age	21.220	23.600	0.341	-0.157	-0.139	0.259	0.417	1.000			
7 M&A	0.984	2.760	0.260	0.077	-0.013	0.183	0.253	0.052	1.000		
8 Diversity	3.500	3.290	0.335	-0.072	-0.062	0.074	0.221	0.173	0.258	1.000	
9 Alliances	9.150	11.700	0.577	0.088	0.050	0.245	0.444	0.171	0.322	0.342	1.000

Table 2.

Variables	**Model 1**	**Model 2a**	**Model 2b**	**Model 2c**	**Model 2d**	**Model 3**
Location	-1.233**	-0.358	-0.826***	-1.021*	-0.479	-0.624***
Investors	-0.123	-0.054	-0.045	-0.103	-0.024	-0.079
Subsidiaries	0.037*	0.030*	0.026*	0.040*	0.024*	0.018**
M&A	0.233*	0.196*	0.173*	0.161*	0.191*	0.103*
Age		0.093*			0.060*	0.056*
Age^2		-4.587E-4*			-4.264E-04*	-2.961E-04*
Employees			2.428E-04*		1.935E-04*	1.139E-04*
$Employees^2$			-2.45E-09*		-2.05E-09*	-1.39E-09*
Diversity				0.473*	0.302*	0.204*
$Diversity^2$				-0.020***	-0.025*	-0.022*
Alliances						0.119*
$Alliances^2$						-0.001**
Diversity.Alliances						0.003***
Employee.Alliances						2.680E-07
Age.Alliances						-7.455E-04*
Log likelihood	-889.5	-863.500	-853.700	-876.635	-836.170	-812.230
LR Test of Delta	1749.5*	1555.6*	1149*	1435.24*	1002.61*	773.41*
Delta	8.99	7.360	6.250	7.930	5.540	4.260

Note: *= p<1%, ** = p<5%, *** = p < 10%

Models 2a, 2b, and 2c respectively examine the positive yet diminishing effects for each of the three absorptive capacity measures: age, employees and diversity. In examining hypothesis 1a, model 2a shows the age coefficient and its quadratic counterpart are, respectively, positive and negative. A similar result is found with the employee variable in model 2b. These results are consistent with Slater and Narvers' (1995) argument that a firm's experiences can promote "dominant logic" behaviors that limit a firm's ability to innovate (see also Christensen and Bow-

er 1996; Hamel and Prahalad 1991). However, unlike these prior authors, a dominant logic does not stem from a myopic focus to the customer. Rather, model 2a and 2b results suggest that such a dominant logic can be attributed to limits with expansions in a firm's absorptive capacity. Namely, increases in a firm's cumulative experiences can yield a confirmation bias in which a firm's search routines diminish a firm's absorptive capacity to bringing products to market. In examining hypothesis 1b, model 2c shows the diversity coefficient and its quadratic counterparts are, respectively, positive and negative. This result is consistent with marketing studies that find a lack of coordination among inter-departmental units can significantly hinder a firm's product development process (e.g. Dougherty 1992; Han et al. 1998; Jaworski and Kohli 1993; March and Stock 2003; Slater and Narver 1995; Wind and Mahajan 1997). In particular, Model 2c's results suggest that excessive increases in a firm's diversity can yield a serial reproduction loss problem that can contribute to this lack of coordination.

As a firm's absorptive capacity can simultaneously consist of a firm's accumulated and diverse knowledge (Cohen and Levinthal 1990), model 2d includes all three absorptive capacity measures. Likelihood Ratio Tests were conducted between model 2d with each of the prior models, 2 a, b, and c. Likelihood Ratio tests reject ($p=0.000$) the null that all three measures of absorptive capacity –age, employees and diversity- are jointly equal to zero. Model 2d shows that a firm's absorptive capacity, age, employees and diversity jointly exhibit a positive yet diminishing effect and are highly significant ($p<1\%$). Hypotheses 1a and 1b cannot be rejected in this model.

To provide a further examination of these diminishing effects, this study draws on a procedure developed by Aiken and West (1991). In linear estimations, a diminishing effect – as reflected by the estimate of the quadratic variable, (i.e. X^2), - can be evaluated by computing its "simple slope" at one standard deviation above the mean value of its main effect, (i.e. X). In this study, simple slopes are reflected by the marginal estimates of the quadratic terms of the absorptive capacity variables. The marginal effects for each of these quadratic terms are then computed at one standard deviation above the mean values of their main effects. However, since negative binomial estimations are non-linear, their simple slopes are dependent on the values taken by all other predictor variables. Hence, to evaluate the diminishing effects for each of the quadratic terms of the absorptive capacity measures, their marginal effects are evaluated at one standard deviation above their mean values, while holding all other variables at their mean values (Graves and Langowitz 1993).

At one standard deviation above their mean values, the marginal effects for each of the quadratic terms, age, employees and diversity, are respectively, -0.00266, -1.28e-08, and -0.1592, and are significant ($p<5\%$). Hypotheses 1a and 1b are not rejected. In particular, as absorptive capacity researchers argue that a firm's experiences and innovation are positively related, this implies that a firm's absorptive capacity is not only positively related to its product performance, but that a firm can introduce products at an increasing rate. This is because since innovations are based on "borrowing" the technical achievements of the past (Cohen and Levinthal 1990), a firm's ability to innovate products in one period reduces the cost of innovating products in the next (Cohen and Levinthal 1989). This follows Anand and Khanna (2000) who note, "firms that have learnt to learn will continue to do so at an increasing rate" (p.298). This suggests a positive coefficient on both the main absorptive capacity variable and its quadratic counterpart. Yet models 2a-d shows

the quadratic estimates for these variables are consistently negative and statistically significant. As a result, even though the magnitude of the diminishing effects is very marginal, the signs on these coefficients reject the argument that continued investments in a firm's absorptive capacity is a source of sustainable competitive advantage (e.g. Bosch et al. 1999; Zahra and George 2002).

To include the role of strategic alliances, model 3 is the full model that includes the absorptive capacity and alliance variable interactions. Relative to model 2d, likelihood ratio tests do not reject the null that the additional alliance and interaction variables are equal to zero (*p=0.00*). In model 3, hypothesis 1a and 1b are not rejected at their mean values and are not rejected at one standard deviation above their means[5]. With regards to a firm's alliances, model 3 shows that a firm's alliances have a positive yet diminishing effect to a biotechnology firm's product performance. This is consistent with prior biotechnology studies (e.g. Deeds and Hill 1996).
To examine their interactions, the interaction effect between age and alliances is significant and negative. Hypothesis 2a cannot be rejected (*p< 1%*). With respect to the interaction effect between a firm's employees and alliances, this interaction was not significant. As age is correlated with employees (see table 1), a separate estimation was conducted that removes the correlated age variable. In this estimation, a significant negative moderating effect was observed. Hypothesis 2a cannot be rejected for this model[6]. This lack of significance is likely attributed to problems of multi-collinearity. These results complement findings reported by Rindfleisch and Moorman (2003) study. They argue that firms with "competitive dominant" alliances will tend to form "overlapping" network experiences that can limit a firm's absorptive capacity in developing innovative product solutions. In their empirical analysis, they find that a firm's alliances negatively moderate a firm's customer / market orientation. From an organizational learning orientation, model 3's findings complement this view by showing a firm's cumulative experiences can negatively moderate the product benefits of a firm's alliances.

With regards to the moderating influences of a firm's diversity, the interaction effect between a firm's diversity and alliances is positive and significant at the 10% level. At this level of significance, Hypothesis 2b is not rejected. This suggests that a firm's diversity of experiences is better suited to assimilating the product benefits of alliances. Although there are no studies that have directly examined such a moderating relationship, Perry-Smith and Shalley (2003) argue and find that a firm's product creation process can positively impact a firm's ability to utilize product alliance information.

Conclusions and Discussions

In high technology settings, innovation and the ability to introduce products to market are intertwined subject areas that have gained significant interest amongst marketing and management scholars (Brown and Eisenhardt 1995; Eisenhardt and Martin 2000; Nerkar and Roberts 2004; Wind and Mahajan 1997). Under hi-technology settings, a firm's "openness" to emerging technologies is instrumental to a firm's product development process because it yields innovative product solutions that are yet to be anticipated by consumers (e.g. Christensen and Bower 1996;

[5] At one standard deviation above their means, the marginal effects for the quadratic terms size, age and diversity, are respectively, -5.88e-09 (p <1%), -0.00125 (p <5%), -0.09149 (p <5%)
[6] Results are available on request.

Hamel and Prahalad 1991; Slater and Narver 1995). In drawing on the concept of absorptive capacity, an "outside-in" learning process was developed to explain this product development process. A key argument of this "outside in" learning process is that a firm's ability to bring products to market depend on not only its cumulative and diverse experiences but also on its ability to gain access to the experiences of its learning partners. Specifically, with this outside in learning process, these experiences are subjective to diminishing return effects and have distinct moderating effects to a firm's ability to internalizing the product benefits of its alliance. This study's empirical findings of the biotechnology industry provide support for this "outside-in" learning framework. This "outside-in" learning framework offers three contributions to product-marketing research and introduces applications / implications to agribusiness.

First, the concept of absorptive capacity offers "an outside in" learning process that complements the "insider-out" learning processes described in the organizational learning literature (Jaworski and Kohli 1993; Slater and Narver 1995). An "insider-out" learning process focuses on an "entrepreneurial" mindset in which the development of product innovations stems from a firm's greater risk taking and product experimentation efforts (Atuahene-Gima and Ko 2001; Jaworski and Kohli 1993; Slater and Narver 1995; Zhou et al. 2005). This study's "outside-in" learning process complements this "inside-out" process because a firm's absorptive capacity and its access to alliances promotes an "openness" to external ideas that can promote the risk taking and product experimentation efforts of this inside-out approach. The implication of this complementary relationship is that this greater openness to external ideas can cultivate a "culture" (Slater and Narver 1995) that focuses a firm to look outward rather than just inward in its product development efforts. Stated different, this "outside-in learning" process can promote an entrepreneurial and innovative cultural mindset to "think outside the box" and has been called for in Slater and Narvers' (1995) learning framework.

Second and building upon Slater and Narvers' (1995) organizational learning orientation, a firm's "outside-in" learning process further broadens the concept of market orientation (Jaworski and Kohli 1993). As this study's outside-in learning process emphasizes a firm's openness to learning partners, a firm's absorptive capacity and its access to alliance partnerships can mitigate the firm from being subject to the "tyranny of served market" (Hamel and Prahalad 1991). Namely, this "outside-in" learning framework broadens a firm's ability to identify its customer's "latent needs" (Slater and Narver 1995). Investments in a firm's technical expertise serves to not only leverage a firm's ability to relate to external technological advances, but in doing so identify commercial applications that are not known by the consumer. For instance, Eli Lilly (e.g. Hoang and Rothaermel 2005; Kale et al. 2002) have developed in house operations whose exclusive function is to assess the commercial value of external technologies and alliance partnerships. As a result, this study's outside-in learning framework can serve to bridge a firm's technology orientation with that of its market orientation. In that, although investments in marketing expertise (i.e. investments in focus groups, sales teams, market segmentation efforts) are important to addressing customers' immediate needs, a firm's investment in this "outside-in" learning process can address its customers' latent needs. The combination of these two processes can thereby improve a firm's long term product performance and has also been argued by Zhou et al. (2005).
Lastly, despite the positive merits from continued expansions in a firm's experiences, Lane et al. (2006) as well as others (Lei and Hitt 1995; Vermeulen and Barkema 2002) have challenged "the continued benefits of such expansions" (Lane et al. 2006; p. 847). That is, in addition to studies

by Lei and Hitt (1995) and Vermeulen and Barkema (2002), this study offers a further explanation as well as empirical evidence that challenge the merits of a continued expansion of a firm cumulative and diverse knowledge experiences. Specifically, unlike Bosch et al. (1999), Cohen and Levinthal (1990), and Zahra and George (2002), this study argues and shows that continued expansion in a firm's cumulative and diverse experiences yields diminishing returns to a firm's product performance. This is because a firm's confirmation bias and serial reproduction loss problem places limits in a firm's ability to assimilate external experiences. Thus, a firm's continued investment in their knowledge experiences is not optimal in sustaining a firm's competitive advantage. Furthermore, as various absorptive capacity researchers have called for a greater integration of the absorptive capacity concept with alliance level investigations (Tsai 2001; Wuyts et al. 2004; Zaheer and Bell 2005), this study contributes to this line of investigation in which a firm's ability to capitalize on the product benefits of its alliances is dependent on the cumulative or diverse nature of their knowledge experiences. That is, although alliances are widely recognized as source of inter-organizational rent (Powell et al. 1996; Rothaermel 2001), the ability to capitalize on such rents – such as through the development of products- is dependent upon the nature and constraints faced by a firm's experiences.

In terms of its applications, this study's proposed "outside-in" learning approach can be offered as one model to explaining potential changes in the product development process of the U.S. agricultural industry. Due to current fiscal realities, reductions in public funding from U.S.D.A. for basic and applied research are likely to induce a greater attention to organizational learning processes. This is because despite the historic contributions made to improvements in agricultural productivity, innovation and subsequent product developments in the agricultural industry have been facing diminished public support. For instance, U.S.D.A funding for research has fallen considerable since the 1990's[7]. More recently for the fiscal year 2010, the R&D budget was 2.61 billion and for fiscal year 2012 has been reduced to 2.373 billion[8]. Such declines will favor an increasing transfer of research responsibilities to the private interests of the agribusiness firm. This is not to say, that public-private innovations partnerships will cease to exist. For example, the recent opening of Dupont Danisco Cellulosic Ethanol plant was the result of a partnership with the University of Tennessee's Biofuels initiative[9]. Yet with current fiscal realities, a model of innovation and product development can no longer be restricted to the "assimilation" and "commercialization" of basic /applied agricultural productivity research, but will likely also require "organizational learning" activities involving private-private learning relationships. Since agribusinesses are distinguished by their interdependence to their value chain partners (Ng and Siebert 2009), the "outside in" learning approach described in this research may thus be one model to explaining this private-private learning relationship. Under such a model, the role of the agribusiness firm is no longer defined by its ability to assimilate and commercialize basic agricultural research (i.e. Dupont Danisco), but may also involve a more pro-active learning orientation in which product development processes depend on collaborations with learning partners of their value chain.

[7] http://www.aaas.org/spp/rd/agri09p.htm
[8] http://www.aaas.org/spp/rd/fy2012/AgricultureOnePageSummary.pdf
[9] http://www.biofuelsjournal.com/articles/DuPont_Danisco_Cellulosic_Ethanol__Genera_Energy__and_University_of_Tennessee_Hold_Grand_Opening_for_Cellulosic_Demonstration_Facility_in_Vonore-88955.html

Such an "outside in" learning approach also raises two implications to agribusinesses. First, agribusinesses involved in an "outside-in" learning approach are likely to engage multiple stakeholders in their product development process. That is, the development of agricultural products is not only intertwined with an agribusiness firm's value chain members, but as a result of this "openness" embeds the product development processes within a network of various stakeholder interests. For instance, the procurement of raw agricultural inputs in the production and packaging of products by multi-nationals, such as Coke (e.g. water stewardship initiative) and Nestle (e.g. creating shared value initiative), are increasingly driven by the interests of its various social and environmental stakeholder groups. Hence, one consequence or implication of this "outside-in" learning approach is a greater openness to these various stakeholder groups not only influences the procurement and development of their food products, but such openness can be one means to help reconcile an agribusiness' private interests with that of the public interests for environmental stewardship. A second and subsequent implication of this outside-in learning approach is the development of agricultural products need not be exclusively driven by the needs and preferences of the food consumer. Rather, such developments can also stem from the interests of the various members of the food supply chain to which enable the agribusiness firm to develop products that food consumers did not anticipate in needing (i.e. Hamel and Prahalad 1991). Hence, unlike a commonly accepted wisdom in agricultural marketing, the food consumer is not the pinnacle of the product development process but is one of many learning partners of an outside-in learning process.

Yet in light of this study's contributions and application / implications to agribusiness, these considerations should, however, tempered by limitations of this study. As this study does not directly tests a firm's confirmation bias and its serial reproduction loss problem, future research calls for a more direct testing of these constructs. In addition, because the concept of absorptive capacity is multi-dimensional, the development of a unified or standardized measure of absorptive capacity remains a subject of much debate (Lane et al. 2006). This study's proposed measures of absorptive capacity are thereby not only subject to limitations surrounding this debate, but the proposed measures reflect one of the many dimensions of this concept. Future research should thereby develop measures that capture others aspects of this concept. Furthermore, even though this study's empirical findings are generally consistent with this study's "outside-in" learning framework, the measures used for the absorptive capacity concept should be interpreted as a precursor for further empirical examinations. In particular, this study chose less direct measures for the absorptive capacity concept so as to minimize the simultaneous causality problem. Yet, in using such indirect measures, they are vulnerable to alternative explanations. For instance, a firm's experience, size and diversity may equally reflect the strength of firms' internal resources rather than just its ability to learn and exploit external knowledge[10]. Hence, future studies should examine more direct measures of the absorptive capacity construct. Such measures would however require developing an IV estimation technique within count data models. This is because although IV estimations have been offered as an alternative solution to correcting simultaneous causality problems, IV estimations are only applicable to linear estimations. Nevertheless, the work done by Mullahy (1997) offers a promising approach to developing an IV for count data model and thus this line of research is called for in future research.

[10] I'd like to thank an anonymous IFAMR reviewer for this point.

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