

**The Dynamics of Firm Knowledge and Competitive Advantage:
A Framework and Case Example**

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Abstract

Even though the description of a dynamic capability is conceptually sound, the processes that help firms avoid the capability-rigidity tendency remain unspecified. To make progress on this the changing position of competitive advantage between two firms is discussed over time. Each firm is examined as a bundle of different types of boundaries and how effectively each firm manages knowledge across them will be used to explain the dynamic capability developed by one and the rigidity trajectory of the other. The framework developed is important because it describes how a dynamic capability can become a source of rigidity. It also contributes to the field of strategic management by providing a conceptual approach that connects the dynamics of firm knowledge to the dynamics of competitive advantage.

Key words: knowledge, managing boundaries, dynamic capability, core rigidity, resource based view, competitive dynamics.

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Introduction

Despite the recognized value of the resource based view (RBV) of the firm (Wernefelt, 1984; Barney, 1991) it has been criticized for its static and under-specified mechanisms for how resources are deployed for competitive advantage (Mosakowski and McKelvey, 1997; Priem and Butler, 2001). The concept of a dynamic capability (Teece, Pisano and Shuen, 1997) has been an important addition to the field of strategic management because it tried to connect the RBV with more intangible resources such as knowledge and its dynamic configuration. Teece and his colleagues argued for such a view when they stated that competitive advantage is achieved by a firm's "ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (1997: 516).

However, despite the value of this conceptual bridge, the processes of how a dynamic capability works remain less than clear. Much of this comes from the tendency of many in the field of strategy to see competencies and knowledge as unproblematic and so are predisposed to black box key strategic processes (Pettigrew, 1992). One of the exceptions to this is Leonard's description of how a core capability can turn into a core rigidity that inhibits competitiveness (Leonard-Barton, 1992). Yet, despite her explanation, the field of strategy still has yet to specify what processes are lacking when a dynamic capability falters and becomes a core-rigidity. Even the knowledge based view (KBV) (Grant, 1996; Kogut, 1996; Spender, 1996), which recognizes a variety of knowledge processes, generally takes an unproblematic view of knowledge—spending very little time identifying the consequences of path dependence and issues of power. Identifying these consequences has only recently come from practice-based views of knowledge

that describe the situated and invested nature of knowledge (Brown and Duguid, 2001; Orlikowski, 2002; Carlile, 2002). Given the complex levels of analysis examined in the field of strategy (i.e., a firm or industry) it is not surprising why researchers tend to abstract key knowledge processes (i.e., transfer, combination or integration) and, thus, underestimate the practical and political costs associated with effectively carrying them out.

Further, to make progress in understanding the processes involved in a dynamic capability within a firm, it is also important to describe the competitive dynamics between firms that generate the competency-rigidity tendency and further expose the problematic nature of knowledge. Given the importance of this larger process of competition, the primary unit of analysis taken in this research will be the boundaries that make up a firm. Instead of viewing the firm as a bundle of resources (Wernerfelt, 1984; Barney, 1991), it will be viewed “as a bundle of different boundaries where knowledge must be shared and assessed” (Carlile, 2004: 566). Comparing firms as a bundle of boundaries allows us to leverage our understanding of the processes of managing knowledge within a firm and link it to the larger “dynamic process out of which competitive advantage arises and then erodes over time” (Cockburn, Henderson and Stern, 2000: 1123). This paper will address how is this larger competitive dynamic is shaped by how competing firms manage knowledge across boundaries?

To begin to address this question a conceptual framework is developed that describes the processes of how knowledge can be managed across the boundaries of a firm and its impact on how a firms’ competitive advantage either rises (dynamic capability) or erodes (core-rigidity). A case study that examines the passenger jet aircraft engine market, specifically the changes that have occurred as General Electric has replaced Pratt and Whitney in the dominant position, will be used to illustrate the value of the framework. To begin the framework that will be used as the core argument of the paper will be outlined.

Knowledge in Practice, Boundaries and Processes at a Boundary

To describe the source of rigidity and processes that support a dynamic capability, a practice-based view of knowledge (Brown and Duguid, 2001; Orlikowski, 2002; Bourdieu, 1980) is taken to explain the challenge of integrating knowledge (Grant, 1996) across the boundaries between the specialized domains. Actors naturally and necessarily draw on their domain specific knowledge and interests to meet the requirements of their given work domain. This dynamic complicates knowledge integration because not only is domain specific knowledge focused in different ways, but those differences often impede knowledge sharing (Carlile, 2002). Acknowledging that knowledge is localized, embedded and invested in a given practice (Carlile, 2002; Suchman, 1988) provides a way to ground an explanation of the problematic nature of knowledge—why past competencies can become a “competency trap” (Leavitt and March, 1988) or a source of “rigidity” (Leonard-Barton, 1992).

Since innovation is required to address competitive realities, the path dependent tendency of knowledge will have to be addressed for a firm to achieve a position of competitive advantage over time. Dorothy Leonard’s (1995) statement that most innovation happens at the boundaries between disciplines or specializations tells us that working across boundaries is a key ingredient of competitive advantage, while also explaining why innovation proves so difficult to create and maintain. The growing research on knowledge in organizations underscores this challenge by recognizing the “knowledge boundaries” (Brown and Duguid, 2001) between specialized domains and that knowledge can be “both a source of and a barrier to innovation” (Carlile, 2002: 442). A firm’s position of competitive advantage is undermined and the competency-rigidity tendency is revealed when a firm poorly manages the relationship between what is currently known and what is new across its bundle of boundaries.

Carlile's (2004) framework for managing knowledge across boundaries when innovation is desired will be used to explain the sources of the competency-rigidity tendency and what distinguishes it from a dynamic capability. What this framework reveals is the tendency of actors in new product development settings to re-use existing knowledge even when novel conditions exist and innovation is sought after. To examine this tendency a distinction is made between domain specific knowledge and the common knowledge used by actors to adequately share and assess each other's domain specific knowledge. The framework outlines the increasing complexity of three types of boundaries—syntactic, semantic and pragmatic—between sources of domains specific knowledge; and the three progressively complex types of common knowledge—common language, common meaning and common interests. Adequately managing knowledge across each type of boundary can be thought of as a process of transferring, translating or transforming knowledge (see top of Figure 1).

Figure 1
The “3-T Framework” for Managing Knowledge across Boundaries

To manage domain specific knowledge across a syntactic boundary a common language must exist and be shared with all the actors involved that specifies the differences and dependencies that are consequential to them. “Price” or a technical “specification” are examples of a common language used at a boundary that specifies the differences and dependencies that are consequential to the actors involved. A sufficient common language doesn't come without effort however; it is created overtime through trial and error between actors. Once established it remains robust so long as the conditions at the boundary remain stable. When novelty arises, the boundary is no longer stable and new sources of difference and dependence need to be identified and their consequences understood. These are circumstances that generate a semantic boundary and the actors involved are required to learn about what differences and dependencies are now

consequential. Under these conditions, a common language is still required, but the current one is no longer sufficient and common meaning needs to be developed. Here the challenge of developing common or shared meanings (Nonaka, 1994) is to learn about and translate each other's knowledge; understanding what differences and dependencies are now of consequence, i.e. given the novelty present, what does "price" mean now? What is the right specification now?

At some boundaries the novelty present generates a situation where it is not simply differences in meaning, but differences in interests as well (Carlile, 2002). These are the conditions at a pragmatic boundary, where common interests must be developed to provide a common knowledge to adequately share and assess each other's knowledge. This type of boundary is the realm of creative abrasion (Leonard, 1995); the actors involved need the ability and capacity to share, negotiate and transform each other's domain specific knowledge (Carlile, 2004). To develop a common language about a price or a specification, conflicts in interests must be recognized, trade-offs must be examined and common interests developed. At a pragmatic boundary the problematic nature of knowledge is recognized, as well as the costs required to transform existing knowledge to adequately represent, share and assess the differences and dependencies now of consequence.

This three-level framework categorizes the relative complexity of the potential boundaries faced by a firm, but also clarifies the relative *capacity* of the processes involved (e.g., transfer through the creation of common language, translation through the creation of common meaning, transformation through the creation of common interest). Further the framework also acknowledges that on either side of the boundary an actors' ability to use a given common knowledge is critical (Black, Carlile and Repenning, 2005). In product development settings when the capacity is not adequate for the type of boundary faced and/or the ability of the actors

to use that capacity is not well matched then the quality of the knowledge produced is poor, resulting in significant delays and costs (Black and Carlile, 2005). Together the *capacity* of the common knowledge present and the *ability* of the actors involved to use it define the *capability* to effectively manage knowledge across a boundary. If the capacity is not adequate and/or the actor's involved don't have an adequate ability to use that capacity then the consequences of the novelty that may be present will not be resolved. This becomes a source of rigidity that must be addressed. The effectiveness of a firm's capability to manage knowledge across its bundle of boundaries is equal the capacity at each boundary given the novelty present times the ability of the actors involved to use that capacity effectively.

This framework, thus, provides the conceptual building blocks to describe a firm as a bundle of different boundaries that must be effectively addressed to avoid the competency-rigidity tendency. In what follows I will primarily focus on the syntactic and pragmatic boundaries of a firm because it is when a pragmatic boundary is faced and a transfer approach is taken that mismatches occur and rigidity follows. But despite not focusing on a semantic boundary it should be recognized that developing a common meaning at a semantic boundary is essential in determining if current knowledge can be re-used or if the existing domain specific and common knowledge needs to be transformed.

Knowledge Dynamics and Dynamic Capability

When new technologies, new ways of organizing, new market needs, new competitors generate novelty in a competitive field, boundaries of a firm become increasingly pragmatic—new differences and dependencies are unknown and their consequences need to be identified and resolved. The value proposition at a pragmatic boundary is transforming a mix of old and new knowledge that supports a *long-term* position of competitive advantage. The value proposition at a syntactic boundary is the efficient transfer of what is known across a given boundary. This

helps a firm maintain its current position, but only provides *short-term* advantage in a competitive field. The scaling the complexity of a boundary from syntactic to pragmatic does have some similarities to the distinction between exploitation and exploration (Holland, 1975; March, 1991), yet the framework's focus depicts this tension not just as opposites that need to be balanced or just complementarities (He and Wong, 2004), but as nested requirements. This hierarchical and nested understanding also suggests that the source of the competency-rigidity tendency of a firm is one where a firm starts by managing novelty through a transformative approach but then over time focuses primarily on knowledge it already values through the efficiency of a transfer approach. Building off Figure 1, Figure 2 represents the bundle of these nested boundaries and types of boundary capabilities that a firm must develop to achieve a position of competitive advantage.

Figure 2
Managing the Bundle of Boundaries and a Firm's Position of Competitive Advantage

The Case: The Passenger Jet Engine Market

To understand how the knowledge dynamics of a firm affects its position of competitive advantage, the civilian aircraft jet engine market will be discussed. Through the 1980's Pratt and Whitney dominated the market over General Electric. Pratt and Whitney's position of competitive advantage had been created through the various technological innovations developed in the early years of passenger jet flight following World War II, such as turbo injection and reverse thruster cooling. Thus, Pratt and Whitney led the domestic jet engine market, particularly as the airline industry began to expand in the 1970's and 80's.

In the early 1990's General Electric began to make slow but consistent inroads into the passenger jet market—eventually taking market share away from Pratt and Whitney in a rather short period of time for such large, integrated industrial product. General Electric accomplished

this by selling the engine at cost and moving to a “service” based business model. Giving such an expensive product away at cost made no sense as each engine can cost over 10 million and the developmental cost of any new engine platform averages around 750 million dollars. Further, with the technological approach to competitive advantage that dominated the industry, selling such a complex product at cost and achieving competitive advantage through serviceability lacked a traditional sense of a “disruptive” (Christensen, 1997) technological threat.

This change to a service approach to competitive advantage was not something that grew naturally from within GE’s technologically driven Jet Engine Division. The serviceability model originated in GE’s Financial Services where they had radically improved their position of competitive advantage by recognizing that they could sell more financial products by looking at the overall lifecycle of the customer; i.e. selling individual financial products cheaper than competitors, with the added attraction of providing an integrated set of products that covered all the needs of their clients. In this way, they could easily out-compete on individual prices, making more money by “capturing” their customers over the long haul by providing a better integrated set of financial products and services to them.

However, going to a service approach to jet engines entailed significantly higher risks. First of all, a jet engine is not a commodity in any sense of the word. Given the technological complexity and financial costs for development, a jet engine represents a much more risky product to sell at cost. Second, focusing on serviceability during the life cycle of the product meant that the engine itself had to be re-designed and built for serviceability. In the end, this second risk was the most difficult thing to pull off because it represented changing both the product architecture (i.e., product/task requirements; Henderson and Clark, 1990) and the organizational architecture (i.e., ways of organizing tasks, career paths, current sources of power and status) of the firm. Here the knowledge used by both the various specialized groups

involved and the knowledge of current differences and dependencies of working together had to be transformed to create an engine that was easily serviceable. For General Electric this novel “serviceability” position of competitive advantage would be an outcome that required tremendous effort in managing a complicated bundle of syntactic and pragmatic boundaries and, more specifically, getting each specialized domain to re-localize and re-invest (and un-invest) their knowledge accordingly.

Changing Customer Needs: Other Sources of Novelty

The potential value for the customer (airline companies) from this risky strategy was that passenger jet aircraft were being utilized much longer than had originally been expected in the 1970’s. Instead of an individual passenger jet lasting 15 years, they were being used for 25 and sometimes 30 years. This durability meant that servicing and re-furbishing engines (the most complex part of the aircraft) represented a huge source of potential revenues. Also, given the tremendous competitive pressures that increased under deregulation in terms of aircraft utilization and on-time arrivals, service was becoming a much more important requirement in how airline companies competed and positioned themselves with their customers and competitors. This, of course, meant that airline companies would pay a premium to service the engines in order to meet their own competitive demands.

The outcome of General Electric’s efforts to move to a serviceability business model has been remarkable. Not only have they become the dominant player in the smaller passenger jet engine market, but they now dominate the larger passenger aircraft market as well. In a decade they have gone from a distant third behind Pratt and Whitney and Rolls Royce to the dominant player in the industry. One reason for the rapid change of fortunes is that this new position of competitive advantage based on serviceability has been very difficult for Pratt and Whitney to replicate, given how localized and invested they were in the capacities and abilities that they had

previously developed. For Pratt and Whitney a new position of competitive advantage could not be reached without significant changes at the bundle of boundaries that are of consequence to them. Their product architecture proved hard to change but, more significantly, the organizational architecture remained invested in the “Cold War” approaches of high performance and cost-plus. Even though Pratt and Whitney identified the novelty of serviceability as important after acquiring service companies, they quickly found out that they could only make money when they serviced General Electric’s engines and, in most cases, lost money when they serviced their own.

Linking Dynamics: Knowledge within Firms and Competitive Advantage across Firms

Using this example of the passenger jet engine industry, I will begin to explain the dynamics of the competitive advantage across firms by first describing the dynamics of what establishes a position of competitive advantage within a firm. Building on Figure 2, Figure 3 represents how, as General Electric moved toward the strategy of serviceability in the early 1990s, it successfully repositioned itself to a “new” position of competitive advantage beyond Pratt and Whitney’s “old” position. To do this, General Electric had to manage the novelty created by their new strategy. For example, GE developed a means whereby engine maintenance people could interact with design engineers and, in some cases, strongly suggest design changes that would enhance the quality and efficiency of servicing an engine, i.e. “design for serviceability.” Involving a maintenance worker in the design of an engine is a novel source of difference, requiring the development of a common language, meaning and interests for representing the dependencies between designers, manufacturing engineers and maintenance personnel. This demands formal changes in the make-up of an integrated product team, as well as changes in the methodologies used, such as who has power to represent their concerns and question the point of view of others.

For the most part, Pratt and Whitney maintained their position, handling the types of differences and dependencies that they were efficient at managing (i.e., skills and knowledge valued, methods and ways of doing product development, a technology orientation toward the customer). These familiar sources of competitive advantage became a competitive syntax (i.e., industry recipes; Spender, 1989) that constrained them in their “current” position, eventually becoming a source of rigidity. Even when they bought service companies to deal with the increasing novelty now present in the industry, this did not transform either the product or organizational architectures of Pratt and Whitney. Since the consequences of the novelty of serviceability were not recognized at the various boundaries that defined Pratt and Whitney, the resources (i.e., technical, political and cultural) required to actually transform the product and the organization were not mobilized. This natural tendency toward the re-use of both domain specific (current resources) and the common knowledge generates path dependencies that result in competency traps (Leavitt and March, 1988) that impede the identification of novelty and the learning necessary to move to a new position of competitive advantage (Carlile and Reberich, 2003). Quite simply, Pratt and Whitney did not establish a dynamic capability (capacities times abilities) to allow a service based strategy to transform how engines were to be designed, built and sold. In contrast, by developing a pragmatic capability at its boundaries, GE established a position of competitive advantage around serviceability.

Figure 3
The Repositioning of Competitive Advantage Overtime (*Note Gray is Figure 2)

By subsuming Figure 2, Figure 3 represents some of the dynamics involved as a GE establishes a new position of competitive advantage beyond Pratt and Whitney’s previous (“old”) position of competitive advantage. Such repositioning assumes both pragmatic and syntactic capabilities (both a transformation and a transfer approach). In firms that successfully re-

position themselves for competitive advantage over time, these two capabilities should not be seen as separate modes (i.e., exploration or exploitation; March, 1991), but nested so equally essential in transforming a mixture of known and more novel forms of knowledge at the various boundaries that make up a firm. Indeed this is not a “static balance, but a dynamic one” (Brown and Duguid, 2001: 208)—one of working out between what is known and what is novel to generates practical and purposeful change.

The Dynamic Process of Competitive Advantage Over Time

To begin generalizing the insights from this case, such strategic “positioning” (Rumelt, 1991) and repositioning is represented as the “old position of competitive advantage,” occupied in our example by Pratt and Whitney, in relation to the “new position of competitive advantage” created by General Electric. The arrows on each side of the competitive field recognize that the position of competitive advantage is dynamic and is accomplished through generating and managing novelty. In the case of an existing firm in a weak position, this is done by recognizing and managing novel differences and dependencies to create new value to improve their competitive position (i.e., GE going to a service based approach). The creation of knowledge that is of strategic value shifts the competitive dynamic that other firms must respond to. For Pratt and Whitney their current position is now the “old” position of competitive advantage, and what is produced by the organization at those “old” pragmatic boundaries no longer provides a sufficient source of competitive advantage. The problematic situation for Pratt and Whitney is that they must transform some of what they know within across boundaries otherwise they will continue to be constrained in their ability to recognize and manage increasing novelty, the new pragmatic boundaries (i.e., serviceability) now present in the industry.

At the same time, such a movement away from their past knowledge within domains and ways of managing it across boundaries (i.e., types of common knowledge) is a significant

challenge for any dominant firm. This reality has been labeled many things: resistance to change, structural inertia, path dependency or the “old” culture. What this also reveals is that the promise of such phrases as “dynamic capability” is essential, but without a better way of describing how such a process is achieved, such an important capability remains under specified and can only be identified ex post. The difficulty lies in the fact that the “old” position is the outcome of previous accumulations of knowledge, where that knowledge had become localized, embedded and invested in various practices, methods, relationships and contracts (i.e., knowledge-in-practice; Carlile, 2002) throughout the firm. As competitive dynamics change and a “new” position is established, the knowledge and ways of recognizing and managing knowledge at the “old” position become a constraint or source of “core rigidity” (Leonard-Barton, 1995).

For incumbent firms building greater efficiency in managing current pragmatic boundaries, rendering them increasingly syntactical, is necessary to free up and shift resources toward recognizing and managing increasing novelty found in a new set of pragmatic boundaries. In the context of scientific progress Bruno Latour (1999) calls this process “black boxing.” For new scientific knowledge to be created current common knowledge (i.e., rules of thumb, critical scientific techniques, methods of experimentation and comparison of data) needs to become simpler and more easy to use (e.g., black boxed) for actors as they share and assess knowledge across the various domains that make up a scientific community. With this increased efficiency the scientific community now has more time to identify and address new pragmatic boundaries—develop new experiments, identify anomalies and develop more useful theories or solutions. For a firm formalizing its capacity to share and assess knowledge across boundaries, this is represented in the logic of lowering transaction costs (Williamson, 1981).

But simply decreasing transaction costs is not enough; firms must use the freed up resources to establish and manage “new” pragmatic boundaries. In scientific communities developing these new boundaries occurs more easily because the effort is distributed across a variety of academic, governmental and corporate research settings. For firms this is difficult because they have fewer settings for new knowledge to be developed and such efforts are naturally constrained by the current efficiencies required to manage less novel boundaries. Given the technical pressure they face with current customers and financial pressures, there is a gravitational pull toward managing efficiently current knowledge and boundaries, thus driving the competency-rigidity tendency.

What about New Entrants?

To create new products or services new entrants must identify and manage novelty by bringing in new domain specific knowledge and new way of managing the boundaries across domains (i.e., new organizational architectures, shared methods, boundary objects). For example, bio-technology firms brought together specialized domains that hadn’t work together before (i.e., physics, mathematics, biology, chemistry, and computer scientists, engineering) under one roof where they developed new methods of doing science and transformed knowledge rapidly across a wider variety of scientific and technical domains than traditional pharmaceutical firms. In smaller bio-technology firms novel differences and dependencies were more easily identified and transformed by scientists and technicians in this fast paced laboratory setting connected to a larger network of “academic” colleagues.

These “new” ways of organizing scientific work proved to be very difficult for established pharmaceutical companies to create. Pharmaceutical firms did not have drug discovery processes, career tracks or cultures that could even attract, let alone manage, such a variety of scientific and technical domains. These firms had large in-house networks of

scientists, but with less capability (capacity and ability) to create rapid scientific break-throughs than smaller, more varied bio-tech firms and their networks. Given the constrained set of differences and dependencies dealt with in large pharmaceutical firms, they either did not identify much novelty or poorly resolved the pragmatic boundary where such novel differences and dependencies existed. The growth of bio-technology firms over the last 15 or 20 years not only has changed how science is done but increased the speed in which discoveries are made and the new pragmatic boundaries that now have to be managed in the pharmaceutical industry.

Role of Customer in the Competency-Rigidity Tendency

The dependencies that a firm has with its customers can have negative consequences on the firm's ability to compete overtime. Christensen argues that one of the primary reasons that a "disruptive technology" emerges is that well established firms are entrenched in their current customer base and established revenue streams (Christensen, 1997). Novelty is often produced by lead users (von Hippel, 1988) but often demanded by less sophisticated customers. New entrants are often in a more natural position to value new, less "sophisticated," lower margin customers because they are not already invested in the high margins and complex technologies of a current set of customers. Because of this new entrants naturally push to create products or services that manage a set of differences and dependencies that customers and competitors currently find difficult to manage (i.e., the problem that serviceability resolved for airlines; cross disciplinary nature of bio-technology).

The particular challenge of an incumbent firm is that their capability of managing boundaries with their customers over time no longer provides an adequate capability for generating competitive success. Given past successes and current customers, this insufficiency is not so easily recognized or resolved, which makes it hard for an incumbent firm to transform its domain specific knowledge or the common knowledge it uses to manage the boundary across

domains. One of the advantages of a new entrant is that they are not as localized and invested in the domain specific and common knowledge used by incumbent firms. From this we better understand that a disruptive technology also requires a disruptive ways of organizing, a capacity for recognizing and managing novel differences and dependencies at its bundle of boundaries. This linkage is another indicator of the relationship between the dynamics of managing firm knowledge and the dynamics of competitive advantage in a given industry.

Being Prescriptive: Scaling the Distance of a New Position of Competitive Advantage

This framework has allowed us to examine the dynamics by which current and more novel forms of knowledge are managed across domains to create a position of competitive advantage. It also allows us to “scale” the relative positions that an incumbent or new entrant has to go in order to create or maintain a position of competitive advantage. For example, the new position of competitive advantage defined by serviceability for General Electric was achieved by transforming the mix of both known and novel sources of knowledge at the bundle of boundaries that make up the firm. For a dominant firm the movement to this position is not easily covered because most often they do not go far enough. For a new entrant the competitive viability lies in its capability to be in a competitive position that is far enough away from incumbents so that incumbents cannot quickly reposition themselves to the new position of competitive advantage generated. However, a new entrant can also go too far out by not recognizing some current differences and dependencies that are still of consequence in generating a position of competitive advantage.

The blind spot for a new entrant doesn't come from being invested in a previous competitive position (the domain specific and common knowledge present), but making sure that the new boundaries it manages also accommodates past differences and dependencies that are still critical for competitive success. We can see this challenge in the case of many of the e-

commerce firms that tried to occupy a position that placed them farther out than traditional “bricks and mortar” (incumbent) firms. In the rages of the dot.com boom many imagined that retailing as done by traditional bricks and mortar companies was in for a significant “virtual” revolution. However, the positioning of many e-commerce firms was not supportable because many of the sources of difference and their complex dependencies were seen only as a part of the old economy (i.e., warehousing, logistics, staffing, training, shipping and returning products) proved to be still critical and could not be supported by an e-commerce website strategy alone. In this case the novelty generated by the possibility of e-commerce did not become a transformed mixture with the knowledge at existing boundaries that were still consequential in the industry.

Most traditional bricks and mortar companies managed these “old economy” sources of difference and dependence effectively and, eventually almost all of these incumbent firms implemented their own web-based technologies that embraced the novel web-based methods of managing their boundaries with the customers before they had suffered too much. We find this evolution captured in the changing language of what it means to be a success in the e-commerce arena. The retailing industry went from “bricks and mortar” being the phrase of the damned to a hybrid “clicks and mortar” strategy of the successful. Using the framework developed here allows us to understand the limitations of the new entrant, e-business strategies, but also the successful competitive position that some new entrant companies such as Amazon.com have established. Amazon.com’s current competitive position is remarkable considering that most surveys place the failure rate of dot.com retailers at over double to non-dot.com plays.

Amazon.com’s unique position occurred because they located themselves at a competitive position that valued and set up technical and social infrastructures to manage known differences and dependencies (i.e., warehousing, shipping and returns of goods, labor issues, etc.) efficiently, but also integrated these with the novel, “virtual shopping cart” (i.e., 1 click patent) and

“personalized website” (i.e., mass customization data base technology) shopping experience with customers.

In the drug industry we see a similar complex set of relations in the competitive arena between incumbent firms (pharmaceutical firms) and new entrants (bio-technology firms). In these changing relations, the relative positions are re-defined with a firm specialization twist that describes the evolving competitive dynamic among them. What large pharmaceutical companies have done to get around their lack of a capability in doing science in “new” and more rapid ways is to increase the level of molecules they buy or “in-license” from 10% in 1988 to over 50% in 1999 (McKinsey Report, 2000) from much smaller, new entrant bio-technology firms. Most bio-technology firms find this of value because as a “newer” entrant they lack the established infrastructures to manage the “institutionalized” bundle of boundaries required in testing and “validating” compounds in clinical trials (i.e., doctor and hospital networks, FDA trial skills). What large pharmaceutical firms lack in managing the bundle of boundaries of doing “new” science is complemented by what small bio-technology firms lack in being able to establish and manage the bundles of boundaries required in successfully steering a compound through clinical trials and approval. In this evolving and more complicated story of incumbents and new entrants we see a current solution in the form of firm “specialization” and narrowly defined partnerships that, when taken together, work to create and deal with the strong (increasing novelty) competitive dynamics in the broader pharmaceutical industry.

Discussion

This approach to describing the dynamics of firm knowledge in terms of a bundle of boundaries extends the resource-based view of the firm (Wernerfelt, 1984; Barney, 1991). Like a resource-based view, the approach developed here explicitly acknowledges the importance of managerial effort in driving innovation long-term, driving it beyond initial success. Yet this

approach offers a more grounded understanding of the rigidity-tendency within firms that constrains such managerial effort. This focus on capabilities at a boundary (capacities x abilities) also resonates with the capabilities perspective that views the firm as a bundle of processes (Rumelt, 1991). By making boundaries as the unit of analysis in explaining the dynamics of firm knowledge, the framework combines both a resource and a capability perspective by describing knowledge both as a content (i.e., domain specific knowledge; resources) and as a process (i.e., common knowledge; competency) that have to be managed. This work has allowed us to be much more specific about the processes, the capacities and abilities that underlie such rich, but abstract concepts as a “dynamic capability” (Teece et. al, 1997; Eisenhardt and Martin, 2000) as well as what is lacking when it falters and becomes a source of rigidity.

The larger dynamic process out of which competitive advantage arises and erodes over time is driven by the generation of novelty in a competitive field. Increasing novelty in a competitive field comes from two different, but co-evolving sources: customers and firms. On the customer side increasing novelty is generated by a set of users who have new needs (i.e., planes that last longer so service and refurbishing become even more important to airlines). This demands new products or services that “black-box” the boundaries—the differences and dependencies that are of consequence to customers and costly for them to manage (i.e., servicing engines quickly, keeping planes in the air, maintaining an older fleet of planes). On the firm side the stretching of a competitive field is generated by a firm (incumbent or new entrant) that identifies novelty and develops a pragmatic capability to manage it along side existing knowledge that remains consequential. This establishes a “new” position of competitive advantage in the industry (i.e., new way of design and building engines at GE; new ways of doing science in Bio-tech; new customer interface for Amazon). This demand and supply for

black boxing is the parallel pull and push that generates a new position of competitive advantage to either an incumbent or new entrant.

At a prescriptive level, the framework developed (Figure 3) outlines a “spatial and temporal” representation of the competitive dynamics between firms over time; representing the process of what is required in moving to a new competitive position where novelty must be addressed; what impedes an incumbent firm from moving far enough; and what is overlooked when a new entrant moves too far out. By representing the spatial and temporal dynamics that define the position and repositioning of firms, we are afforded an understanding of the relationship between the dynamics of firm knowledge and the larger dynamics in a competitive field. The framework also identifies the process at a boundary to maintain a dynamic capability (i.e., identify and manage a new set of pragmatic boundaries) that help avoid the competency-rigidity tendency when novelty is present. Focusing on managing knowledge across boundaries allowed us to be very concrete about the sources and causal processes that lead to the competency-rigidity tendency in firms.

There are limitations with the connection developed in this paper between the knowledge dynamics within firms and larger competitive dynamics across firms. First, what is offered is only grounded in a limited case presentation. Second, the sheer scope of the questions is indeed large, demanding further work and iteration between empirical and conceptual efforts that examine the relationship between what firms do and competitive dynamics over time. However, the value of the framework comes from two sources. First, the conceptual links between firm and competitive dynamics have not been made; this effort is a useful start in developing a language that describes these dynamics. Second, the actual dynamics of knowledge as described within the firm is grounded in a series of empirical studies (Brown and Duguid, 1991; Carlile, 2002; Carlile, 2004; Black et. al, 2005)—so the framework is rooted in a concrete understanding

of what generates successful collaborations and products at a boundary. For this reason this work should be seen as a critical conceptual step in better linking our understanding of the dynamics of knowledge within a firm to larger competitive dynamics.

Conclusion

The framework developed explains how the success of past knowledge can lead to the core competency-core rigidity tendency in a firm. By describing the firm as a bundle of boundaries where both known and more novel forms of knowledge needs to be managed I outlined three types of boundary and their respective transfer, translation and transformation processes. Further, the common knowledge developed to manage domain specific knowledge across boundaries shapes the organization (Lawrence and Lorsch, 1967) and product architectures (Henderson and Clark, 1990) of a firm. As novelty arises and new pragmatic boundaries emerge existing architectures can lead to rigidity because the processes they support are no longer adequate in managing knowledge effectively across the firm's bundle of boundaries.

For the incumbent firm, the value of its current knowledge and processes of managing boundaries is a rational one because it positioned the firm favorably in the past and to abandon that knowledge (i.e., customer base, technological approach, etc.) has political and cultural ramifications and poses known financial risks. The long-term requirement for the incumbent firm is to be able to move far enough out to recognize and manage the novel sources of difference and the dependencies of consequences across the various boundaries that affect the firm. For the new entrant the opposite is often the case because going too far out is likely to avoid managing some of the differences and dependencies that remain consequential to successfully delivering a valued product or service.

A position of competitive advantage does not just arise from boundaries internal to the firm, but arises from its relation to others firms (incumbent and new entrant) and customers (new markets) that together generate the dynamic process of competitive advantage. Although the challenge is different for incumbent and new entrant firms, both types of firms must engage in a process of transforming a pragmatic mixture of current and more novel forms of knowledge at its boundaries to generate a position of competitive advantage. It is at this complex bundle of boundaries that a firm must develop adequate capabilities to remain dynamic and address the core competency-core rigidity tendency. It is in this pragmatic space, between what is novel and what is currently known, where a firm's position of competitive advantage arises, is maintained or erodes.

References

- Barney JB. 1991. Firm resources and sustained competitive advantage. *Journal of Management* 17: 99-120.
- Black L, Carlile PR, Repenning N. 2005. Expanding theoretical insights from ethnographic evidence: building on Barley's study of CT-scanning implementations. Forthcoming in *Administrative Science Quarterly*.
- Black L, Carlile PR. 2005. Latent problems in product development: constraints on the production of knowledge across boundaries. Working Paper, Boston University School of Management, Boston, MA.
- Bourdieu P. 1980. *The Logic of Practice*. Cambridge University Press: Cambridge, UK.
- Brown JS, Duguid P. 1991. Organizational learning and communities-of-practice. *Organization Science* 2: 40-57.
- Brown JS, Duguid P. 2001. Knowledge and organization: a social practice perspective. *Organization Science* 12: 198-213.
- Carlile PR. 2002. A pragmatic view of knowledge and boundaries: boundary objects in new product development. *Organization Science* 13: 442-455.
- Carlile PR. 2004. Transferring, translating and transforming: an integrative framework for managing knowledge across boundaries. *Organization Science* 15: 555-568.
- Carlile PR, Reberich E. 2003. Into the black box: the knowledge transformation cycle. *Management Science* 49: 1180-1195.
- Christensen C. 1997. *The Innovator's Dilemma*. Harvard Business School Press: Boston, MA.
- Cockburn I, Henderson R, Stern S. 2000. Untangling the origins of competitive advantage. *Strategic Management Journal* 21: 1123-1145.
- Cohen WM, Levinthal DA. 1990. Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly* 35: 128-152.
- Eisenhardt K, Martin J. 2000. Dynamic capabilities: what are they? *Strategic Management Journal* 21: 1105-1121.
- He Z, Wong P. 2004. Exploration vs. exploitation: an Empirical test of the ambidexterity hypothesis. *Organization Science* 15: 481-494.
- Henderson R, Clark K. 1990. Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly* 44: 83-111.

- Henderson R, Cockburn I. 1994. Measuring competence? Exploring firm effect in pharmaceutical research. *Strategic Management Journal* 15: 63-84.
- Holland JH. 1975. *Adaptation in Natural and Artificial Systems*. University of Michigan Press: Ann Arbor, MI.
- Kogut B, Zander U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science* 3: 383-397.
- Kogut B. 1996. What firms do? Coordination, identify and learning. *Organization Science* 7: 502-518.
- Latour B. 1999. *Pandora's Hope: Essays on the Reality of Scientific Studies*. Harvard University Press: Cambridge, MA.
- Lawrence P, Lorsch J. 1967. *Organizations and Environments: Managing Differentiation and Integration*. Harvard Business School Press: Cambridge, MA.
- Levitt B, March JG. 1988. Organizational learning. In *Annual Review of Sociology*, W.R. Scott and J. Blake (eds.). Annual Reviews: Palo Alto, CA; 319-340.
- Leonard-Barton D. 1992. Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal* 13: 111-126.
- Leonard-Barton D. 1995. *Well Springs of Knowledge: Building and Sustaining the Sources of Innovation*. Harvard Business School Press: Cambridge, MA.
- March J. 1991. Exploration and exploitation in organizational learning. *Organization Science*: 71-87.
- McKinsey Quarterly, 2000. A license to cure. *McKinsey Quarterly* 1: 20-28.
- Mosakowski E, McKelvey B. 1997. Predicting rent generation in competence-based competition. In *Competence-Based Strategic Management*, Neene, A., Sanchez, R. (eds.). Chichester: Wiley; 65-85.
- Nonaka I. 1994. A dynamic theory of organizational knowledge creation. *Organization Science* 5: 14-37.
- Orlikowski W. 2002. Knowing in practice: explaining effective knowledge sharing in distributed organizing. *Organization Science* 13: 249-273.
- Pettigrew A. 1992. The character and significance of strategy process research. *Strategic Management Journal* 13: 5-16.
- Porter M. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. Free Press: New York, NY.

Prahalad CK, Hamel G. 1990. The core competencies of the corporation. *Harvard Business Review* May-June: 79-91.

Priem R, Butler J. 2001. Is the resource-based 'view' a useful perspective for strategic management research? *Academy of Management Review* 26: 22-40.

Rumelt RP. 1991. How much does industry matter? *Strategic Management Journal* 12, 165-185.

Spender JC. 1989. *Industry Recipes: The Nature and Sources of Managerial Judgment*. Basil and Blackwell: Oxford and Cambridge, UK.

Spender JC. 1996. Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal* 17: 11-25.

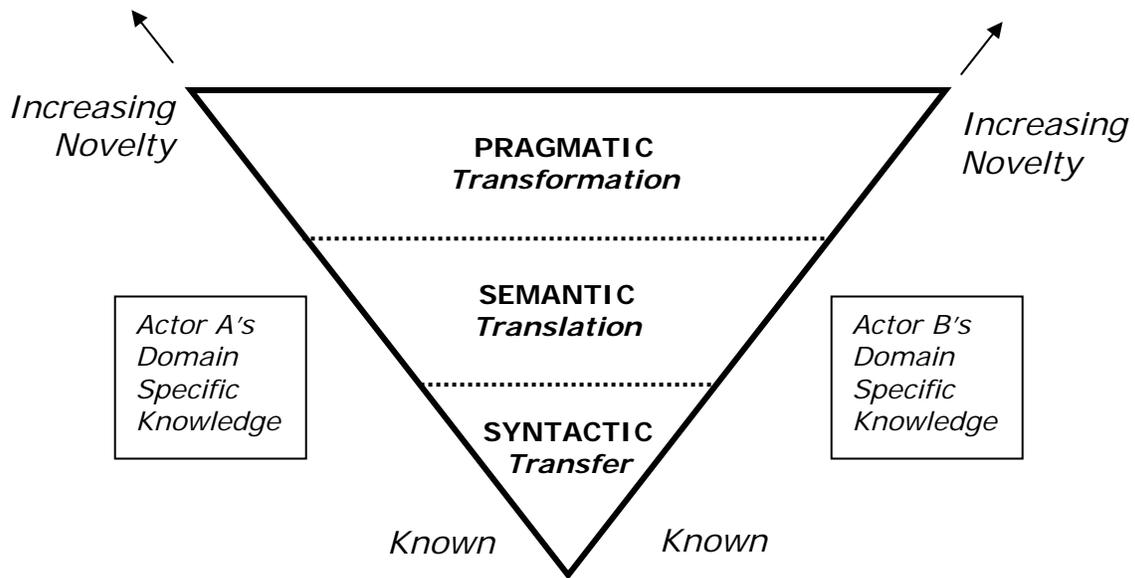
Teece D, Pisano G, Shuen A. 1997. Dynamic capability and strategic management. *Strategic Management Journal* 18: 509-533.

von Hippel E. 1988. *The Source of Innovation*. Oxford University Press: New York, NY.

Wernerfelt B. 1984. A resource based view of the firm. *Strategic Management Journal* 5: 171-180.

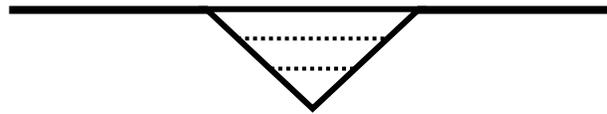
Williamson O. 1981. The economics of organization: the transaction cost approach. *American Journal of Sociology* 87: 548-577.

Figure 1
The “3-T Framework” for Sharing and Assessing Knowledge across Boundaries

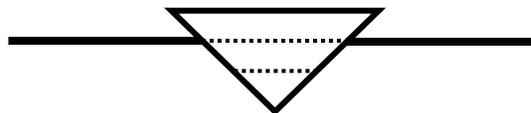


Type of Boundary and Common Knowledge (Capacity) Required

Type of Boundary: Pragmatic
Required Capacities: Common Language, Meaning and Interests



Type of Boundary: Semantic
Required Capacities: Common Language and Meaning



Type of Boundary: Syntactic
Required Capacity: Common Language



Figure 2
Boundaries and a Firm's Position of Competitive Advantage

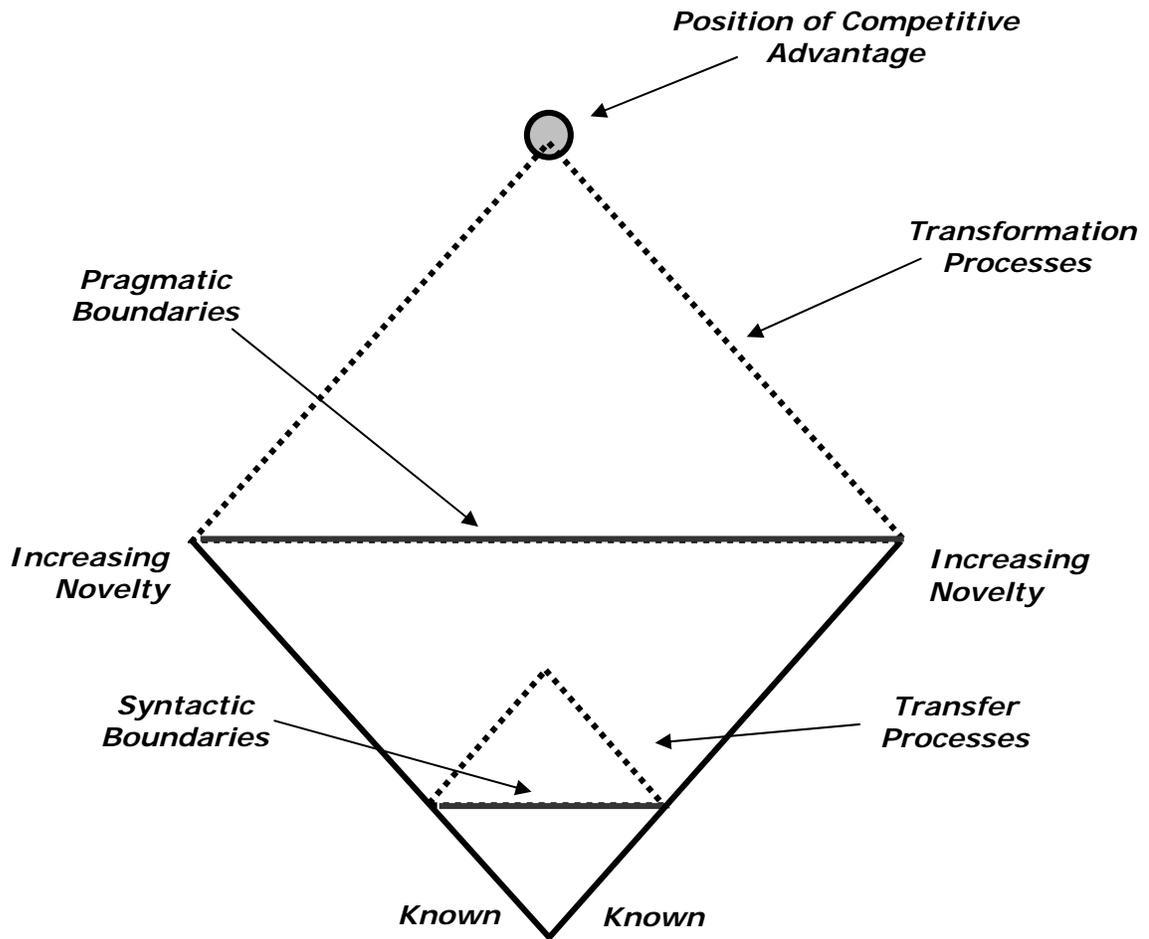


Figure 3
The Dynamic Process of Competitive Advantage Overtime (*Note Figure 2 is Grey)

