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## AVOIDING COMPETENCE SUBSTITUTION THROUGH KNOWLEDGE SHARING

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**Causal ambiguity protects distinctive competencies from imitation but might increase a firm's vulnerability to substitution. We suggest that firms can manage this tension by identifying the causes of superior performance and using this knowledge to make their commitments to key stakeholders more credible. Credible commitment allows a firm to influence its stakeholders and thereby simultaneously delay substitution and control the threat of imitation.**

Resource-based theory has had a tremendous influence on strategic management research during the past 15 years (Barney, 1991; Rumelt, 1984; Wernerfelt, 1984, 1995). Of its four cornerstone conditions (Peteraf, 1993), the theory's explanation for the persistence of competitive advantage and above-normal returns has received the greatest attention. Advocates of the theory maintain that resources that are well protected from imitation can be a durable source of advantage, and authors have discussed numerous mechanisms that increase the costs of replication (Ghemawat, 1986a; Mahoney & Pandian, 1992). However, resource-based theorists identify two threats to competitive advantage: imitation and substitution. Substitution largely has been neglected.

Our primary objective here is to extend resource-based theory by exploring how firms can combat the threat of competence substitution. We focus on advantages accruing to the knowledge components of a firm's distinctive competence, since unique knowledge is believed to be the most fundamental source of above-normal returns (Spender, 1996; Teece, 1998). Proponents of resource-based theory suggest that knowl-

edge-based advantages are difficult to imitate when the reasons for superior performance cannot be identified or controlled (Dierickx & Cool, 1989; Lippman & Rumelt, 1982). A firm can purposefully develop competence around tacit, firm-specific knowledge and complex sets of activities to increase their ambiguity (Reed & DeFillippi, 1990), but these imitation barriers cannot prevent competence substitution.

To delay substitution, we suggest that a firm can raise the level of performance that its competitors believe is necessary for substitution to be profitable. This might limit the amount of innovative activity directed at replacing a firm's distinctive competence. We identify three strategies that a firm can use to build this barrier to substitution: continuous improvement, lock-in, and market deterrence. To implement these strategies, a firm needs explicit knowledge of the factors that affect its performance, both to accelerate learning and to influence key stakeholders. However, as a firm acquires explicit knowledge, it reduces the level of causal ambiguity that protects its distinctive competence from imitation. Thus, our secondary objective is to clarify how causal ambiguity affects the duration of competitive advantage.

The dilemma is that while ambiguity slows the diffusion of superior practices and technologies across firms, it impedes the creation of new knowledge within the firm. The net effect on the persistence of advantage is unclear. We ar-

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gue that since a firm must simultaneously avoid substitution and imitation, it cannot maximize the duration of its competitive advantage solely by escalating imitation barriers. Instead, their height must be managed so that a firm can minimize both of these threats.

The article is organized as follows. First, we discuss difficulties associated with sustaining competence-based competitive advantage. Next, we explain how firms can build barriers to substitution through continuous improvement, lock-in, and market deterrence. We then propose how firms can use explicit knowledge to execute these strategies and identify boundary conditions that increase the likelihood of each being used. To conclude, we discuss directions for future research.

## SUSTAINING COMPETENCE-BASED COMPETITIVE ADVANTAGE

### Distinctive Competence

A *distinctive competence* is a firm's ability to do something better than can its competitors (Andrews, 1987; Hofer & Schendel, 1978; Selznick, 1957). This ability is a source of competitive advantage and above-normal profits when it enables a firm to offer unique (and valued) products or services or to achieve higher performance on common criteria, such as quality, costs, or timeliness (Conner, 1991; Peteraf, 1993). The ability to achieve these criteria stems from competence in many hierarchically related activities, where each activity can be decomposed into successively more specialized tasks (Grant, 1997). Each task targets subsidiary goals that collectively produce performance on firm-level criteria.

At any of these levels, a firm's unique knowledge of how to organize productive activities, transform physical resources, and match these to specific customer needs is fundamentally responsible for superior performance (Spender, 1996). The benefits embodied in tangible resources are available to any firm that purchases them, but firms learn idiosyncratic things about the resources they use, which enables some firms to exploit resources more profitably than others (Penrose, 1959). This unique knowledge resides in a firm's management practices, technical specifications, and business plans—where it is relatively well articulated—and in the skills

and knowledge of its employees and their shared routines—where it tends to be more tacit (Gersick & Hackman, 1990; Leonard-Barton, 1992; Nelson & Winter, 1982; Pentland, 1992).

A firm sustains competitive advantage from a distinctive competence as long as rivals cannot match its level of performance or offer more desirable criteria. Competitors may replicate or surpass a firm's performance by copying its unique practices or technologies, or by finding substitutes for them. To prevent this, a firm must build barriers to imitation and substitution.

### Barriers to Imitation

According to resource-based theory, a distinctive competence can be a sustainable source of advantage if it is in limited supply or if a firm's competitors incur higher costs to acquire it (Peteraf, 1993; Wernerfelt, 1984). Yet, the supply of a capability rarely will be constrained by physical factors, and legal mechanisms do not effectively protect many of them (Levin, Klevorick, Nelson, & Winter, 1987). Also, unlike tangible resources, most knowledge cannot be traded on well-functioning markets, where its price to competitors would rise as more firms recognized its value (Arrow, 1962). Instead, competitors might replicate a firm's performance for a lesser expense by exploiting knowledge that inadvertently spills outside the firm's boundaries (Camp, 1989; Mansfield, Schwartz, & Wagner, 1981).

Consequently, intrinsic characteristics of capabilities, such as their complexity, tacitness, or specificity, might provide the best protection against imitation, because they obscure the sources of superior performance (Amit & Schoemaker, 1993; Reed & DeFillippi, 1990; Winter, 1987). Ambiguity about which performance criteria are valuable and how to achieve them, or which contingencies affect implementation, may forestall imitation by increasing uncertainty about what to copy and by raising the costs of doing so (Barney, 1991; Lippman & Rumelt, 1982; Schoemaker, 1990).

In support of this, Szulanski (1996) found causal ambiguity to be one of the primary factors hindering best practice transfer within firms, and we expect it would frustrate efforts to transfer practices across organizational boundaries to at least the same degree. Teece (1977) found that firms incur higher costs to transfer

poorly understood technologies, which is consistent with the resource-based arguments. And firms do sometimes bribe or hire away knowledgeable employees to learn about a competitors' superior capabilities (e.g., see Besanko, Dranove, & Shanley, 1996; Carley, 1998; Starkman, 1997). These intelligence-gathering practices will be less productive when employees can explain little about how a firm achieves superior performance.

Conversely, when causal ambiguity is reduced, a firm's performance advantage may erode. Rogers (1995) found that new practices and technologies are adopted more quickly when uncertainty about their performance benefits decreases. Armour and Teece (1978) showed that the profits gained by using the M-form corporate structure diminished as this structure became widely adopted. Powell (1992) discovered that performance differences could be attributed only to the use of strategic planning in populations of firms where this practice had not diffused widely. Similarly, the gap in quality levels between U.S.-made and Japanese-made automobiles appears to have narrowed as U.S. firms have gained proficiency with many of the total quality manufacturing practices used by their Japanese competitors (*Manufacturing Engineering*, 1996; Phillips, 1997; Winter, 1993).

However, causal ambiguity also prevents a firm from learning from its own experience and from improving its performance over time (Hedberg, 1981; Huber, 1991; March & Olsen, 1975). Further, if a firm does not understand the causal structures that affect its performance, its efforts to respond to changes in the environment (e.g., new customer preferences or technological opportunities) will succeed only by chance (Collis, 1994). The confluence of inert performance levels and environmental change creates opportunities for competitive substitution, and a firm lacking causal knowledge has little chance of responding successfully.

### The Threat of Substitution

Substitution is the use of alternative resources or capabilities to achieve a given criterion or to produce outcomes that make that criterion obsolete (Barney, 1991). For example, Barney (1992) has suggested that a charismatic leader and a formal planning system are substitute resources for achieving coordination. Substitutes that are

equivalent (i.e., generate the same level of performance) or superior will erode the rents to a firm's distinctive competence.

A *substitute competence* is one based on an alternative set of management practices, technology, and/or business model. However, many minor variations on a particular competence can arise as the competence is modified to suit individual firms. We view these variations as being closer to imitation than substitution. Therefore, we further define substitutes as embodying a fundamentally different approach to achieving a given objective—that is, embodying a different "problem-solving approach" (Dosi & Marengo, 1993). This type of substitution can occur at any level of competence.

Canon's challenge to Xerox is an example of competence substitution. Canon attacked Xerox's advantage in photocopiers by developing the capability to manufacture high-quality copiers, which substituted for Xerox's extensive technical service capabilities (Porter & Ishikura, 1983). Both capabilities achieve the objective of keeping the copier up and running for customers. More recently, Saturn compensated for its weaker manufacturing capabilities by developing superior service capabilities (McGahan, Hax, & Keller, 1994). Superior automobile quality and effective service capabilities both reduce the amount of time customers spend having their cars repaired. In both examples, firms used a different set of activities to achieve a performance criterion, which represents an alternative approach to solving that particular problem.

Technologies that exploit different physical properties of raw materials or utilize a distinct design approach are based on substitute competencies. For example, x-ray imaging equipment is based on knowledge of how short waves of radiation behave, whereas nuclear imaging equipment is designed to exploit the behavior of gamma rays (Mitchell, 1989). In products that are designed according to the principles of modularity, each component is assigned a distinct function, whereas in those based on integral design principles, many components are relied upon to achieve a particular function (Ulrich, 1995). Management practices and governance modes based on decentralized rather than centralized decision making, and autonomous rather than hierarchical coordination, may likewise substitute for one another (Aoki, 1986; Rediker & Seth, 1995).

These examples suggest that the threat of substitution is ubiquitous. It occurs through the introduction of new business models, more efficient management practices, and technological innovation. In fact, substitution can be viewed as the essence of competitive strategy because, short of targeting a different market, it is what a firm must do to avoid competing on another firm's strengths and its own relative weaknesses. Even competitive threats that we typically refer to as imitation entail substitution of resources and capabilities. For example, generic drug producers are frequently referred to as product imitators, since they do not discover new drugs. Yet, their business model is based on alternative resources and capabilities (e.g., low-cost manufacturing and high-volume distribution channels) that enable them to compete for the same customers as R&D-intensive pharmaceutical firms.

If substitution appears viable, causal ambiguity will be insufficient to sustain an advantage. Instead, we argue that a firm needs explicit knowledge of performance drivers in order to shape organizational and competitive processes that determine how quickly its existing competencies are substituted for. Explicit knowledge can be used to create barriers to substitution. Although a firm cannot directly prevent competitors from investing in substitutes, it might persuade them that substitution is unlikely to be profitable. In particular, a firm might use its unique knowledge to convince competitors that good substitutes for its distinctive competence do not exist. Whereas the height of an imitation barrier corresponds to the cost of replication, the height of a substitution barrier can be conceptualized as the "performance hurdle" that substitute competencies must clear in order to be a source of rents.

In the following section we discuss three strategies that a firm can use to create substitution barriers: continuous improvement, lock-in, and market deterrence. The first strategy is used to increase substitution barriers by improving a firm's own performance, the second by forcing suppliers and customers to incur switching costs should they take their business to another firm, and the third by making the market look unattractive to other firms. To implement each strategy, a firm needs to understand the drivers behind its own superior performance. This explicit knowledge can be used to make credible

commitments<sup>1</sup> to key stakeholders, and thereby gain their cooperation in carrying out these strategies.

These strategies most likely will be used when there is a need for credible commitment, methods of credible commitment that do not involve revealing explicit knowledge (e.g., putting a reputation for behaving in specific ways at risk) are less viable, and firms can minimize the risks associated with imitation. Table 1 summarizes the propositions and the boundary conditions.

A general boundary condition is that the propositions apply to complex competencies. A firm is better able to manage the level of causal ambiguity by sharing partial knowledge if its distinctive competence consists of many different components. Therefore, the risks of imitation are lower. Also, knowledge sharing is more valuable when competencies are complex and the factors driving a firm's performance are ambiguous. Under these conditions, knowledge sharing can be used to enhance the credibility of a firm's commitments by making performance drivers more evident to certain stakeholders. Next, we describe these strategies in greater detail. We begin each section by identifying a particular type of substitution and we then describe how substitution might be delayed, explain why credible commitment is needed, and propose how knowledge sharing can help a firm make its commitment credible.

## STRATEGIES TO DELAY SUBSTITUTION

### Continuous Improvement—Commitment to Employees

Distinctive competence may be based on superior management practices. For example, ex-

<sup>1</sup> *Commitments* are actions, such as investing in resources or writing enforceable contracts, that lock a firm into a particular pattern of behavior for substantial periods of time (Ghemawat, 1991; Milgrom & Roberts, 1992). A firm can use to its advantage the fact that its future actions are limited to influence the behavior of other economic agents (Besanko et al., 1996; Tirole, 1989). However, commitments must be credible—that is, a firm must incur a substantial cost to back out of them—if they are to have this strategic value, and a firm's commitments must be observed to affect stakeholder behavior (Dixit & Nalebuff, 1991; Schelling, 1960). This definition is distinct from that used in the organizational behavior and human resources management literature, where commitment refers to an employee's devotion or loyalty to a particular firm (Meyer & Allen, 1991).

TABLE 1  
Knowledge-Sharing Strategies and Their Boundary Conditions

Source of Performance Advantage	Strategy to Delay Competence Substitution	When Credible Commitment Is Most Valuable for Executing Strategy	When Knowledge Sharing Is Most Valuable for Credibly Committing	When Associated Risks from Imitation Are Minimal
Management practices (i.e., ways of organizing and coordinating activities)	Continuous improvement: credibly commit to reward employees for the level of performance they achieve by <i>exchanging</i> management practices with competitors	Employees have reason to resist continuous improvement, such as when they need to acquire firm-specific knowledge, exert extra effort, or bear additional risk to achieve a firm's improvement goals.	Factors that drive performance are ambiguous. A firm lacks other methods of committing, such as staking a reputation for treating employees fairly.	Competencies are complex or protected by other barriers. Competitors target different market segments, or direct competitors face a common threat.
Technology (i.e., product or process design parameters)	Lock-in: create credible commitments not to exploit customers and suppliers by <i>sharing</i> technology to invite some competition into the market	Customers or suppliers have to make large, irreversible investments to use or support a firm's products.	Factors that drive performance are ambiguous. A firm lacks other methods of committing, such as staking a reputation, or the future of other exchange relationships with the same customers and suppliers.	Competencies are complex or protected by other barriers. Competitors target different customer segments, or direct competitors are substantially weaker.
Business model (i.e., set of activities used to serve a market segment)	Market deterrence: demonstrate credible commitment by <i>publicizing</i> business model to discourage other firms from serving the same customers	A firm's market segment is not protected by other entry barriers, and the firm would incur substantial costs to switch to another market.	Factors that drive performance are ambiguous. The resources that credibly commit a firm to defend its market position are unobservable.	Competencies are complex or protected by other barriers. The firm shares relatively little information about how to implement its business model.

cellence in product quality, research productivity, and customer responsiveness stems largely from better ways of organizing and coordinating productive activities (Clark & Fujimoto, 1991; Garvin, 1988; Grant, 1996; Hayes & Clark, 1985; Henderson & Cockburn, 1994). When such competences arise from many different or interdependent practices, they are hard to copy. Competitors not only will require time to identify all the relevant practices but will need time to implement them. Each practice must be tailored to the imitator's idiosyncratic resources, and employees need experience using them to accumulate the tacit knowledge that enables them to solve problems and coordinate distinct activities efficiently (Barley, 1996; Nelson & Winter, 1982; Pentland, 1992; Tyre & von Hippel, 1997).

However, competitors can develop substitute management practices to overcome these barriers. A firm might delay the introduction of alternative management practices by continuously improving its own level of performance. Continuous improvement leverages a firm's prior experience and enables it to benefit from asset mass efficiencies and time compression diseconomies<sup>2</sup> (Dierickx & Cool, 1989). This increases

<sup>2</sup> This means that a firm's ability to improve is constrained by the amount of experience it has and that committing more resources to a project cannot accelerate learning. Therefore, firms with less experience will never catch up, unless they develop substitutes that produce much better performance. Deliberate efforts to achieve continuous improvement are necessary to benefit from these barriers; per-

the performance hurdle to substitutes and might reduce competitors' efforts to compete on the same criteria, if it makes the existence of better methods appear unlikely.

Yet, continuous improvement can be exceedingly difficult for successful firms to achieve. Whereas the employees of poorly performing firms may question the adequacy of their practices, highly performing firms lack the motivating gap between aspirations and performance (Cyert & March, 1963; Milliken & Lant, 1991). Superstitious learning can lead to complacency, and innovation might appear riskier to a successful firm than a poorly performing firm that does not jeopardize its advantage by experimenting (Bromiley, 1991; Levitt & March, 1988). Both good performance and cumulative experience can lead to political, cognitive, and structural rigidity and increase resistance to change (Hannan & Freeman, 1984; Lewin, 1947; Tichy, 1983).

Variable compensation schemes, which link pay and other benefits to the level of performance employees achieve, may reduce these inertial tendencies<sup>3</sup> (Banker et al., 1999; Fast, 1975; Ghemawat, 1992; Rumelt, 1995). By focusing attention on performance outcomes, they provide incentives to experiment outside the boundaries of legitimated practices. Although there is evidence to suggest that variable pay can facilitate continuous improvement, many firms avoid tying compensation very tightly to performance, because these policies are diffi-

formance improvement is not an automatic outcome of experience (Bohn, 1995; Dutton & Thomas, 1984; Hatch & Mowery, 1998).

<sup>3</sup> Empirical evidence exists that some firms have successfully used variable pay to achieve continuous improvement. Lincoln Electric is an oft-cited example of a company that has been able to improve productivity continuously, and its managers attribute much of the firm's success to its piece-rate compensation system (Fast, 1975; Miller, 1992). Ghemawat (1992) has argued that Nucor's superior financial performance is due, in part, to its success in tying compensation to continuous productivity gains. Banker, Lee, Potter, and Srinivasan (1999) found that a large retail company was able to improve sales productivity continuously by linking bonus pay to a prespecified sales goal over a 2 1/2-year period. They show that these effects are due both to sales agents' efforts to improve their selling capabilities and a selection effect—less productive employees leave the firm. These studies support the proposition that variable compensation helps to reduce tendencies to rely on existing processes and can contribute substantially to a firm's continuous improvement objectives.

cult to implement (Baker, Jensen, & Murphy, 1988; Bennett, 1991). The challenge is to devise a reward structure that is both appropriately motivating and binding on individual managers.

Specifically, Miller (1992) has maintained that variable pay policies often fail because managers cannot credibly commit themselves to stick to agreed-upon performance goals and compensation rates. They often lack much of the information needed to design fair and effective variable pay policies (Lawler, 1987). To set compensation rates that are sufficiently motivating, a firm must know how much effort a task requires, and since variable pay forces employees to bear more risk, the compensation arrangement also needs to account for this (Milgrom & Roberts, 1992). The degree of risk involved in meeting particular objectives might be influenced by variance in the improvements new practices generate, implementation contingencies, and the extent to which performance outcomes are within the control of employees.

Much of this knowledge can be acquired by exchanging information about management practices and associated performance outcomes with other firms, through benchmarking arrangements, academic studies, and industry associations (Bean & Gros, 1992; Camp, 1989; Zenger & Hesterly, 1997). Exchanging knowledge in this way enables a firm to base its inferences about performance drivers on a larger, more diverse sample of data. A firm then can use this explicit knowledge to design compensation policies that effectively encourage continuous improvement. For example, a firm can learn about the effort involved in achieving certain criteria by evaluating data on performance levels, resources (e.g., amount of time, people), and practices others have used to organize and coordinate specific activities. By observing implementation barriers that other firms have encountered and variation in the performance levels attained, managers gain insight into how much risk employees bear.

Without this information, conditions might arise that tempt managers to alter variable pay contracts after they have been implemented. Policies are sometimes modified because they do not effectively motivate employees. If performance goals are set too low (or compensation too high), managers might wish to raise standards later. However, this creates a ratchet effect—that is, employees subsequently have in-

centives to withhold effort, since good performance is expected to lead to tougher pay policies (Weitzman, 1980). Yet, if specified targets are not met because of unanticipated contingencies, managers might feel pressure to award bonuses anyway. This practice can diminish future effort, for employees will expect compensation regardless of the level of performance they achieve. In some cases managers stand to gain directly by reducing compensation rates or raising performance targets *ex post*, such as when they are rewarded for the profitability of a particular organizational unit (Miller, 1992).<sup>4</sup>

Reneging is also more likely if it carries minimal penalties, such as when the terms of an agreement are unclear to begin with. Ambiguity enables parties to an agreement to construct equally justified but conflicting positions about the appropriate way to deal with unforeseen circumstances, making it hard to determine who has violated the intent of the contract. By exchanging knowledge, managers and employees can reduce ambiguity about likely barriers to achieving their performance goals, decide who bears responsibility for addressing certain types of contingencies *ex ante*, and thereby raise the penalty imposed on those who do renege. Agreements that are designed with this knowledge in hand are likely to be more effective and binding on the managers responsible for implementing and enforcing them. Thus, we expect the following.

*Proposition 1: A firm can delay substitution through continuous improvement by exchanging knowledge of management practices, process performance, and implementation contingencies, and by using this knowledge to credibly commit to variable pay policies.*

<sup>4</sup> Early studies of labor relations provide vivid examples of this "reneging behavior" (Whyte, 1955). For example, managers of the Hovey and Beard toy company were surprised when production workers achieved productivity, with a new technology and organizational changes, that was 50 percent above the expected level (Bavelas & Strauss, 1955). This raised compensation far above that provided for other tasks similarly skilled employees performed, and those employees began to complain. Managers subsequently reduced the piece-rate bonus in an effort to raise profits and appease other employees; not surprisingly, productivity also dropped. Some evidence suggests that employees continue to be wary of performance-based pay (Miller, 1992; Milne, 1996).

A firm might benefit the most by sharing knowledge with competitors who employ the same technology and business model, because they face common constraints on the types of management practices they can use, as well as the level of performance they are likely to attain with them. However, the risks of imitation are also greatest if a firm shares knowledge with direct competitors. To minimize this risk, a firm might share knowledge with competitors that target different customer segments. If products and services are differentiated vertically (i.e., via attributes that enhance the value of a good for customers but decrease its value to other customers), the price of one good does not affect demand for the other (Besanko et al., 1996). This expands opportunities for knowledge trading, as indirect competitors can each improve their level of performance without eroding the others' profits (von Hippel, 1987).

Knowledge trading also might occur within strategic groups. Strategic group members may use comparable management practices because of commonality in the scope of their operations, market conditions, technology, and other resources. Owing to these similarities, firms within a strategic group also are likely to be threatened by common forces. For example, regional banks might share knowledge with one another in order to compete against national chains when members of the other group pose a greater threat to a firm's market share than do its own group members. Generic drug manufacturers might cooperate to improve productivity in order to compete more effectively against R&D-intensive pharmaceutical firms, as long as their primary opportunities to gain market share come at the expense of firms in the other group. Similarly, domestic competitors might share knowledge to battle foreign rivals who benefit from different labor or factor market conditions (Carter, 1989).

If strong substitutes exist for a product and customers make investments that are either specialized to those products or to substitutes for it, a firm might share its practices with competitors. Automobile manufacturers, for instance, invest in expensive molds and equipment that are specialized to either steel or composite materials and, therefore, are reluctant to depend on the well-being of individual suppliers. Steel producers might share information with one another in order to enhance the cost effectiveness of steel

relative to composites. Accordingly, we expect the following.

*Proposition 2: To minimize the risks associated with imitation, a firm is most likely to exchange its management knowledge with industry competitors that target different market segments or with direct competitors that face a common threat (e.g., from substitutes or firms in other strategic groups).*

### **Lock-in—Commitment to Suppliers and Customers**

Technological competencies often are challenged by substitute technologies (e.g., products based on different core components, processes that utilize alternative equipment, or competing technical standards). A competitor with competence in substitute technologies might be able to replicate or surpass the firm's costs or product performance without having to imitate the focal firm's capabilities. Although continuous innovation might be necessary in this situation, its value against substitute technologies is unpredictable, because each technology's rate of improvement is constrained and facilitated by different factors. A more certain strategy is to "lock in" customers and suppliers.

Lock-in is created when customers or suppliers make firm-specific investments in skills, knowledge, equipment, and/or organizational processes to use or support a firm's products. These investments mean that customers and suppliers will incur a significant cost if they shift their business to another firm, since these assets will lose value and since new skills and equipment may be necessary to use another seller's product. As a consequence, the firm's exchange partners will delay purchasing, or developing for, a substitute technology until the performance benefits compensate for their adjustment costs (Lieberman & Montgomery, 1988). In addition, by slowing the rate at which customers and suppliers migrate between sellers, lock-in provides firms with more time to adapt their own products and services to match the performance benefits a substitute technology offers (Mitchell, 1989; Tripsas, 1997).

Customer switching costs increase if complementary goods and services, which are incom-

patible with competing technology, influence a product's value. Therefore, a firm might further delay substitution by encouraging suppliers to develop specialized complementary products—that is, products that only work with the firm's technology. In this circumstance potential competitors must not only develop a product with substantially superior performance to attract customers but might also incur the expense of identifying and cultivating a new set of complementary goods suppliers. Thus, lock-in raises the cost of developing a substitute technology, because competitors must improve product performance to a degree that compensates for the switching costs customers incur, and they might also have to invest in a new supply network.

Based on these arguments, one would expect that the larger the firm-specific investment the customers and suppliers make, the more secure a firm's advantage is likely to be. However, customers and suppliers are more vulnerable to ex post opportunism by sellers when switching costs are great (Williamson, 1985). Once a customer has made a specialized investment, the firm can raise its price or cheat on quality relatively easily. Suppliers also become more vulnerable to opportunistic behavior once they make specialized investments to develop complementary goods and services for a firm's products. For example, the firm could modify its product platform in a way that makes some complementary products irrelevant or that forces suppliers to incur large costs to adapt. If customers realize this *ex ante*, they will be less willing to purchase the firm's products; if suppliers think similarly, they may be less willing to tailor their offerings to the firm.

A firm can try to assure its exchange partners that it will not engage in such *ex post* opportunistic behavior by writing long-term contracts. However, these contracts are not credible unless most of the contingencies that could affect product price and/or performance specifications can be specified in advance (Milgrom & Roberts, 1992). If the capabilities required to develop a product are complex, it can be exceedingly difficult to predict even the basic elements of an exchange contract with customers and suppliers. The costs of developing a complex product are affected by fluctuation in a wide variety of factor markets, and complexity makes it difficult to anticipate design choices and performance tradeoffs that may arise. These factors may pre-



clude accurate projections of completion dates, development costs, and overall product performance, thereby making any contractual agreements incomplete.

When imitation is likely to occur only very slowly, a firm might need to encourage some competition in its product market to overcome its inability to write complete contracts and credibly commit not to exploit its customers and suppliers. In particular, a firm can credibly commit not to behave opportunistically by sharing information about its technology (e.g., licensing at low royalty rates or releasing technical standards) in order to invite at least one additional firm into the market (Conner, 1995; Farrell & Gallini, 1988; Shepard, 1987). Guaranteeing that customers have a second source for the product credibly commits the firm to compete on price and/or quality over time, because customers can then shift to the firm with the best performance or lowest price. Similarly, suppliers might be reassured that the firm will treat them fairly, if they can easily transfer their productive activities to another seller.

In prior studies researchers have shown that buyers often insist firms demonstrate that at least one additional seller exists before they are willing to be locked into the firms' technology (Swann, 1987; Taylor, 1984). Customers routinely demand that sellers license a second source in the computer and electronics industries (Carbone, 1996; Chaney, 1995; Longwell, 1995), and anecdotal evidence suggests that this practice is used in other industries. Conner (1995) notes that if customers or suppliers must choose between competing technologies, they are more likely to select the one that is supported by multiple firms, because they are insured against future monopolistic behavior. This can increase a firm's chances of setting the dominant technology standard and can further delay substitution as the benefits from positive network externalities increase the value of the firm's products. Shepard (1987) and Farrell and Gallini (1988) have shown that, when setup costs are high, credible commitment through information sharing can raise a firm's profits by increasing demand. In this way a firm might encourage imitation to delay substitution.

*Proposition 3: A firm can delay substitution by sharing technological knowledge with at least one other*

*firm, thereby credibly committing not to exploit its customers and suppliers and persuading them to make large firm-specific investments to purchase or support its products.*

Enabling imitation clearly is risky. However, by sharing knowledge before it diffuses, a firm can select which competitors are able to copy its technology first and thereby minimize the long-term impact that imitation has on its profits. By populating the industry with "good" competitors, a firm might discourage stronger (more direct) rivals from entering (Rockett, 1990). For instance, a firm might share technological knowledge with competitors having different complementary capabilities (distribution channels or service or marketing capabilities), thus being positioned to serve slightly different customer segments. Covering the market in this way reduces opportunities for profitable imitation, since an entrant will have to share its niche with the incumbent, who has had time to move down the learning curve for the technology. Along these lines, Conner (1995) suggests that technology sharing can benefit the innovator if licensees cover lower-end market segments or markets that require very different complementary capabilities.

There is still a risk that licensees might use the shared knowledge to improve their own capabilities and surpass the incumbent's product performance or achieve lower costs. However, licensing also can reduce competitors' incentives to engage in more radical innovation that could replace a firm's technology (Gallini, 1984; Gallini & Winter, 1985). Therefore, we suggest the following.

*Proposition 4: To minimize the risks associated with imitation, a firm is most likely to share its technological knowledge with weaker or differentiated competitors.*

#### **Market Deterrence—Commitment to Competitors**

A third important threat of substitution comes from those competitors using an alternative set of activities—that is, a substitute business model—to serve the same market segment. This threat frequently arises from established firms seeking to deploy their competencies in new

markets (Geroski, 1991). A successful incumbent might delay substitution if it can convince these potential entrants that the market segment it occupies is not the most profitable place for them to deploy their capabilities. One strategy for reducing the perceived attractiveness of a market is for the incumbent to demonstrate that it is credibly committed to compete aggressively with entrants.

If the incumbent's capabilities are complex and market specific, this credibly commits it to compete aggressively to defend its market, because capabilities with these attributes lose value in alternative uses.<sup>5</sup> The expected rate of return from deploying complex, market-specific capabilities in alternative markets is much lower. Therefore, the incumbent requires a rate of return to remain in its current market that is lower than the rate of return that would entice a firm that has not developed these capabilities to enter the market. This allows the incumbent to credibly signal that it has an incentive to sustain lower prices than the potential entrant is willing to bear.

However, since capabilities are not visible, the incumbent might need to publicize information that illustrates their complexity and specificity. Only observable commitments have any effect on competitors' behaviors. Articles and cases that describe the components of Wal-Mart's distribution capabilities, for instance, help to convey their complexity and demonstrate that they are tailored to serving a specific segment of the retail industry: discount retail (Ghemawat, 1986b). By sharing information about its business model, the incumbent can reduce some uncertainty about how efficient it really is, but this does not provide sufficient information for entrants to accurately predict the firm's costs. The nature of the remaining uncertainty also has important implications for a firm's ability to deter market entry.<sup>6</sup>

<sup>5</sup> By definition, market-specific capabilities are less valuable in other uses, because they are tailored to satisfying performance objectives certain customers value more than others. If these capabilities are also complex, they might be more costly to adapt to other uses.

<sup>6</sup> An alternative strategy is for an incumbent to charge a low price to indicate that market demand is limited or that its marginal costs are low (Matthews & Mirman, 1983; Milgrom & Roberts, 1982). The challenge for the incumbent is to persuade potential entrants that it has an incentive to keep

Lippman and Rumelt (1982) have shown that if entrants can only attain the level of efficiency they need to break even with some degree of uncertainty, entry into a market might cease before all above-normal profits are eliminated. They model uncertainty as risk—or the variance in a distribution of performance levels that incumbents have achieved—and find that the greater the uncertainty, the quicker entry will diminish. Therefore, we might expect that entry will cease faster when an incumbent's distinctive competencies are complex, because the level of performance firms attain is likely to vary more owing to difficulties associated with implementing complex capabilities (Mosakowski, 1998).

However, uncertain imitability can deter entry only if firms seek to replicate the incumbents' capabilities, rather than develop substitutes for them. Since the contingencies associated with implementing substitute business models might be quite different, the chances of success might also vary substantially. Rather than risk, firms that consider entry by substitution face Knightian uncertainty or ambiguity about their chances of success (Knight, 1921). The rate of entry under ambiguity might be higher than when potential entrants are sure of the probabilities of success for two reasons. First, studies suggest that market entrants tend to be overly confident about their abilities to succeed (Baldwin, 1995; Busenitz & Barney, 1997; Dunne, Roberts, & Samuelson, 1988). Entrants are especially overoptimistic when profits are determined by a firm's skill or competence relative to competitors, compared to when profits are determined by exogenous, uncontrollable forces (Camerer & Lovallo, 1999). Individuals expect skill to help them beat the odds, and excess optimism is likely to persist when information about the factors affecting a firm's chances for success is noisy, infrequent, or ambiguous (Camerer & Lovallo, 1999; Kahneman & Lovallo, 1993).

A second decision-making bias might also operate to influence market entry rates: ambiguity

its prices low after entry occurs, even though this is often not the case. The incumbent might persuade others that it is credibly committed to price aggressively by sharing some of its unique knowledge, as described here, but at the same time maintaining a sufficient level of uncertainty so that potential entrants cannot be certain about the firm's costs (Saloner, 1983).

seeking—or the propensity to choose ambiguous bets over risky ones when the odds of success are low. If a market segment already is populated by at least one very strong competitor, this should reduce the probabilities that entrants assign to their odds of success. But if entrants know little about the incumbent's capabilities, they cannot be very certain about these probabilities. The resulting ambiguity actually might increase potential entrants' optimism about their chances of success. Uncertainty about the odds might be resolved favorably; therefore, if given a choice between bets where the probabilities are the same and low, individuals will tend to prefer to the ambiguous bet (Einhorn & Hogarth, 1986; Highhouse & Hause, 1995).

This suggests that an incumbent may slow entry into its market more effectively if it shares information about its superior business model than if it maintains complete secrecy. If having knowledge about the incumbent's distinctive capabilities persuades potential entrants that substitutes are unlikely to exist and leads them to believe that imitation is their best option, then the level of ambiguity surrounding potential entrants' chances for success is reduced. We expect knowledge sharing to have an important influence on potential entrants' expectations because, as Nelson (1991) has argued, business innovation is an extremely uncertain enterprise owing to the lack of scientific theory to guide entrepreneurial search. Since business models cannot be derived from theory, managers must learn about the performance tradeoffs associated with alternative models through their own experience, or through the experiences of others.

The search for new business models, thus, is heavily shaped by a firm's prior experience, beliefs that are transferred within communities of practice (e.g., professional and industry associations), and heuristics gleaned from the business press (Abrahamson, 1991; Best, 1990; Chandler, 1992; Wenger, 1998). Legitimated examples of the way others have solved a particular business problem might be especially influential in shaping the way managers think about achieving certain performance objectives. As industry recipes accumulate, managers are apt to weigh evidence that confirms their superiority more heavily than evidence that questions it (Klayman & Ha, 1987; Spender, 1989). Consequently, once such beliefs are established, they can be

very difficult to change, and a business model might be taken for granted as the best way to serve a particular market segment for a substantial period of time. While these beliefs prevail, potential entrants might be less inclined to search for substitutes. These arguments suggest the following.

*Proposition 5: A firm can delay substitution by publicizing core elements of its business model and their performance advantages, to demonstrate its credible commitment to the market and to persuade potential entrants that alternative business models cannot deliver the same performance criteria as efficiently.*

By disclosing the performance benefits and components of its business model, an incumbent might increase the risk of imitation. However, we expect this risk to be minimal when the incumbent's capabilities are complex, because identifying the elements of its business model conveys a relatively small proportion of the knowledge needed to replicate the model's performance. The incumbent would not share the details of how it manages specific activities, because this is what generates variation in performance levels associated with a complex capability; thus, imitation still is an uncertain undertaking. Further, as long as entrants do not expect substitutes to be as efficient as the incumbent's business model, potential entrants might use the variance in prior entrants' performance to assess their chances of success. If the incumbent's capabilities are complex, this variance is likely to be high, and entry should cease before all profits erode (Lippman & Rumelt, 1982). Therefore, we propose the following.

*Proposition 6: To minimize the threat of imitation, a firm that publicizes the advantages of its business model is likely to withhold information about how it manages those activities.*

## DISCUSSION

Researchers working in the resource-based tradition have enriched our understanding of imitation barriers by identifying mechanisms that increase the costs of replication (Ghemawat, 1986a; Mahoney & Pandian, 1992) and

classes of resources that are inherently tough to copy (Barney, 1986; Barney & Hansen, 1994; Castanias & Helfat, 1991; Wernerfelt, 1989). Causal ambiguity, as well as characteristics of competencies that give rise to it, has been a particular focus in studies of knowledge resources (Barney, 1991; Dierickx & Cool, 1989; Reed & DeFillippi, 1990; Teece, 1998; Winter, 1987). Perhaps because this literature has offered such intuitive explanations for the persistence of competitive advantage, little attention has been given to the threat of resource substitution.

With this article we seek to fill this gap. We suggest that substitution barriers can be conceptualized as performance hurdles, and we discuss three strategies to build them: continuous improvement, lock-in, and market deterrence. Each strategy requires the cooperation of certain stakeholders, whose payoffs from cooperation are contingent upon the firm's future behavior. A firm can persuade its stakeholders to cooperate by credibly committing to carry out specific promises or threats. However, to make its commitments credible, a firm needs to reduce causal ambiguity about the conditions surrounding its execution. Ambiguity prevents stakeholders from verifying that the firm actually has incentives to behave as it says it will.

A firm can use explicit knowledge to make its incentives more apparent to its stakeholders in a variety of ways. Explicit knowledge can be used to make contractual commitments credible (Proposition 1). A firm can reduce the temptation to renegotiate or back out of its contractual agreements, regardless of their formality, by ensuring that all parties understand, *ex ante*, the forces that may influence how well the terms are likely to be met. When it is difficult to gather the knowledge needed to make contracts a credible means of commitment, a firm can instead share its explicit knowledge to influence other forces, such as competition, that affect its incentives to behave in particular ways (Proposition 3). Alternatively, a firm may reveal some of its unique knowledge to demonstrate that it already has strong incentives to take certain actions, such as when it is committed by characteristics of an unobservable resource like distinctive competence (Proposition 5).

These strategies for delaying substitution complement those discussed by advocates of the dynamic capability perspective (Teece, Pisano, & Shuen, 1997). The focus of this perspec-

tive is turbulent competitive environments, where it is assumed that a firm's existing competencies will quickly become obsolete because of technological change. Rather than attacking substitutes head on, firms are urged to look for opportunities to redeploy their capabilities in new markets and to continuously develop new competencies (Prahalad & Hamel, 1994).

In contrast, we have explored how a firm might delay the substitution of its existing competencies. We suspect that a firm needs to be active on both fronts and that even new competencies must in some way leverage a firm's experience. Extant competencies are more reliable, and they define the domains in which a firm can recognize and act on opportunities ahead of its competitors (Cohen & Levinthal, 1990; Hannan & Freeman, 1984). Without these advantages, a firm's strategy has no better chance of success than a *de novo* firm (Teece, Rumelt, Dosi, & Winter, 1994).

However, the dynamic capability perspective has led us to question the extent to which firms need to avoid both imitation and substitution in all contexts. Extant theorizing seems to imply that substitution is a more important threat in turbulent contexts than imitation. This derives from the observation that if product cycles are extremely short, competitors might have little time to copy a firm's products. Instead, there is more value in focusing on the next product generation, with the result that competitors engage in parallel innovation more than imitation. It would appear that in this type of environment, competence substitution occurs continuously, but this is not necessarily true for all levels of competence.

Product design capabilities might change frequently, whereas competencies at higher levels, such as those used to develop product platforms or core components, remain relatively stable (Meyer & Utterback, 1993; Sanderson & Uzumeri, 1995). Barriers to imitation and substitution may be equally important for protecting a firm's higher-level competencies. Furthermore, frequent change is not necessarily disruptive. In fact, some studies suggest that the new technology content of products in turbulent industries is low (Bayus, 1998). This reinforces the importance of strategies that prolong the value of extant competence. In future studies researchers could usefully elaborate these distinctions by describing competence hierarchies and investigating

the dynamics of imitation and substitution at multiple levels in particular industries.

Research on the multilevel nature of competencies also would help to clarify the role of causal ambiguity in prolonging competitive advantage. The literature's emphasis on ambiguity and tacitness has generated concern over the theory's relevance to managers. If the sources of superior performance must remain ambiguous, then researchers and consultants cannot develop prescriptions for managers that lead to higher profits in equilibrium. For example, Barney argues:

If it was possible to tell a large number of firms how to modify their cultures to include economically valuable attributes, then culture would cease to give any one firm a competitive advantage and could not be a source of sustained superior performance (1986: 663).

We have sought to resolve this dilemma by exploring how the knowledge gained when causal ambiguity is reduced can be used to prolong competitive advantage. If explicit knowledge helps delay substitution, as we have proposed, then lowering causal ambiguity does not necessarily jeopardize a firm's advantage.

There remains a great deal of work to be done, however, to describe the distinct and synergistic roles of explicit and tacit knowledge in sustaining competence-based advantage. Nonaka (1994) has developed some important ideas about the mutually reinforcing roles of tacit and explicit knowledge in the creation of new knowledge. Additional research is needed to relate both knowledge types to the persistence of competitive advantage. Our first set of propositions suggests that explicit knowledge about a particular activity can be used to offset inertial forces in its constituent tasks. Conversely, the tacit, firm-specific knowledge that accumulates around subordinate tasks might prolong the advantages derived from explicit knowledge.

The last two sets of propositions suggest that, at some levels of competence, explicit knowledge might be more valuable if it is made public, where it can influence the expectations and behavior of a firm's competitors, customers, and suppliers. We believe this is an especially rich area for further research. In certain markets a firm may prefer to face competitors that rely on competencies that are similar in some respects, provided there is sufficient room to differ in other areas. For instance, in markets character-

ized by positive network externalities, a firm might prefer to face competitors using the same technological standards (Henderson, 1999). Or competitors might seek to avoid technological rivalry by utilizing common product components but unique business models. Knowledge sharing may have an important role to play in shaping these competitive dynamics (Das & Van de Ven, in press; Spencer, 1999).

To test the propositions presented here, researchers need to focus on the relationship between a firm's knowledge-sharing strategy and its relative performance on the criteria that define its distinctive competence, rather than on the firm's dominance in an industry or market. These criteria delimit the market space in which a firm has a competitive advantage. Some criteria might make a firm's products or services valuable to all customers for those goods, whereas others might appeal to certain segments of the market. Some distinctive competencies generate criteria that are embodied in multiple products (e.g., Honda's competence in developing fuel-efficient engines). The strategies discussed here should protect a firm's advantage in each market segment where these criteria are embodied.

To investigate the performance implications of these strategies, scholars would need to measure how the level of causal ambiguity affects a firm's profits. This requires a setting where knowledge flows can be controlled, such as in experimental markets. In field studies researchers can explore how knowledge sharing affects performance outcomes that stem directly from distinctive competencies (e.g., a cost or quality advantage), as well as the mediating processes (e.g., the efficacy of variable pay policies, supplier/customer commitments and loyalty, and market entry rates) that affect the persistence of an advantage. Empirical research in this area could generate evidence on when the benefits of delaying substitution are likely to outweigh the reduced rents from faster imitation, and whether other performance tradeoffs are involved.

Finally, we have sought to identify boundary conditions for each strategy. With additional research scholars could identify variables in specific industries that affect these conditions and elaborate how a firm goes about sharing knowledge (e.g., exactly when and how much knowledge a firm reveals). The three modes of knowledge use—exchanging,

sharing, and publicizing—that we discussed earlier could be used to orient such studies.

The literature on informal knowledge trading (Carter, 1989; Schrader, 1991; von Hippel, 1987) and benchmarking (Bean & Gros, 1992; Camp, 1989; Matzko & Wingfield, 1995; McNair & Liebfried, 1992) indicates that firms do exchange explicit knowledge, as we have suggested. However, in this literature the authors tend to assume that only direct solutions to specific problems are sought through these channels. Firms might also trade knowledge to learn about general phenomena (e.g., the effort involved in certain tasks) to enhance their ability to design policies (e.g., compensation) that have more lasting effects on the nature of their competencies.

Similarly, the literature on licensing and technological standards suggests that firms sometimes share technological knowledge with competitors, and trade journals illustrate that customers in a variety of industries, including steel, electronics, computer hardware, and chemicals, demand second sources. Yet, we know little about how firms manage these relationships. Scholars could examine how firms share technological knowledge with competitors in order to alter their relationships with customers and suppliers, which types of firms are selected to be second sources, and what steps firms take to maintain performance advantages vis-à-vis firms they share this knowledge with.

Examples of firms that have publicized core elements of their business model (e.g., by writing articles for trade journals or by granting interviews to journalists and academics) also exist. Researchers could explore how potential competitors use this knowledge. To what extent do potential entrants actively gather information about incumbents' capabilities, and how does it affect their entry decisions? Formal models of market entry often contain the assumption that firms use available information in a rational manner, but experimental studies suggest that decision-making biases might operate to affect entry behavior. This research could be complemented usefully with field studies. Research on the diffusion and exchange of technological knowledge through networks offers some ideas about how firms acquire such knowledge, as well as some of the factors that influence how they exploit it (e.g., Debackere &

Rappa, 1994; Liebeskind, 1996; Podolny & Stuart, 1995).

## CONCLUSION

With this article we offer a conceptual bridge between static and dynamic views on competence-based competitive advantage. Specifically, we illustrate how a firm might sustain such an advantage by discovering the static sources of its superior performance (e.g., its management practices, technology, and business model) and by using that knowledge to shape dynamic processes (organizational learning, technology adoption, and market entry) that affect the value of its distinctive competencies. These processes are driven by the choices a firm's stakeholders make. We have described how a firm may influence those choices by sharing its unique knowledge in order to shape stakeholder beliefs and expectations about the firm's future behavior. We hope others will build on these ideas to further explain how firms can affect the organizational and competitive processes that drive competence imitation and substitution.

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