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THE SECOND FACE OF APPROPRIABILITY: GENERATIVE APPROPRIABILITY AND ITS DETERMINANTS

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We distinguish between two forms of appropriability: primary appropriability—effectiveness in exploiting inventions as problem-solving mechanisms and capturing a share of their *profits*—and generative appropriability—effectiveness in exploiting inventions as concepts and capturing a share of the future *inventions* they spawn. Recognizing that generative appropriability has two components—cumulative invention and preclusion of others—we identify its key managerially manipulable determinants and discuss the implications of the construct for the literature on the resource-based view and the literature on organizational learning.

The issue of appropriability—that is, how firms can appropriate value from their inventions—represents a fundamental problem in strategy research (e.g., Teece, 1986). In most appropriability research, scholars have focused on the idea that inventions create value for firms by being translated into products or by being licensed out. However, from the time of Arrow (1962), and possibly earlier, researchers have recognized that there are usually at least two facets to any invention. On the one hand, an invention is a solution to some technoeconomic problem, a source of enhanced utility or lower cost for some set of beneficiaries; on the other hand, an invention is a concept, an idea that adds to our universe of concepts and ideas and that can itself become a seed for future concepts and ideas. Thus, Arrow's (1962) abstraction suggests that any invention potentially creates two types of value: an intrinsic value that relates to the problem-solving aspect of the invention and a fecundity, or generative, value that relates to its potential as a springboard for future inventions (Hopenhayn & Mitchell, 1999).

It follows, then, that for every invention a firm faces two distinct appropriability issues: (1) how it can capture the greatest share of profits from the problem-solving invention it has developed—that is, benefit from the utility that its invention directly creates for a user—and (2) how it can capture the greatest share of future inventions that are spawned by its invention and thereby benefit from the new element it has added to the universe of ideas (cf. Fleming, 2001).

The first type of appropriability, "primary" appropriability (PA), refers to a firm's effectiveness in exploiting a given invention by translating it into a product or licensable solution for users (e.g., Teece, 1986)—"primary" because for each generation of inventions, the achievement of profits and, thus, the realization of a return on the investment made tends to be a first-order or primary goal. The second type, "secondary" or (henceforth) "generative" appropriability (GA), refers to a firm's effectiveness in capturing the greatest share of future inventions spawned by its existing inventions. Future inventions could be enhanced or improved versions of the original invention (addressing the same needs as the original invention and, hence, potential substitutes for it), or derived inventions that use the ideas of the original invention in a related but complementary market (e.g., iPad tablets building on iPhone) or even in unrelated markets

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(e.g., skin cleanser Clarisonic building on the principle of ultrasound vibration embodied in an electronic toothbrush, Sonicare).

The strategy literature has focused mainly on PA. However, it is likely that in contexts where inventions occur with some frequency and existing products are supplanted fairly often, firms may seek both to enjoy *the profits* associated with a given invention as above (PA) but also to ensure that their research efforts bear fruit in the form of *multiple sequential inventions* (GA) that sustain their value creation over time. In this article we elaborate the construct of GA, highlighting its theoretical and managerial distinctiveness and significance; identify key managerially manipulable determinants of GA; and explore its implications for the literature on the resource-based view (RBV) and the literature on organizational learning.

DEVELOPING AND CLARIFYING THE GA CONSTRUCT: THE DISTINCTION BETWEEN PA AND GA

Imagine a firm that in Period 1 releases Invention 1. At that time the firm faces a PA and a GA problem. First, it needs to use the *problem-solving* aspect of Invention 1 to *create a profit*, identifying the best way to monetize it—as a commercialized product or through licensing. Second, recognizing the *conceptual* component of Invention 1, the firm may use the principles embodied in the current invention to *originate new inventions*. Success in this second endeavor will lead the firm to release an Invention 2 in Period 2 that builds on the concepts embodied in Invention 1. This begins a cycle where the firm has to find (1) how to translate Invention 2 into a stream of financial returns and (2) how to build on the idea in Invention 2 to come up with Invention 3 in Period 3 (see Figure 1), and so on. Thus, the two appropriability questions arise iteratively for an initial invention as well as for any subsequent inventions that originate from it.[1]

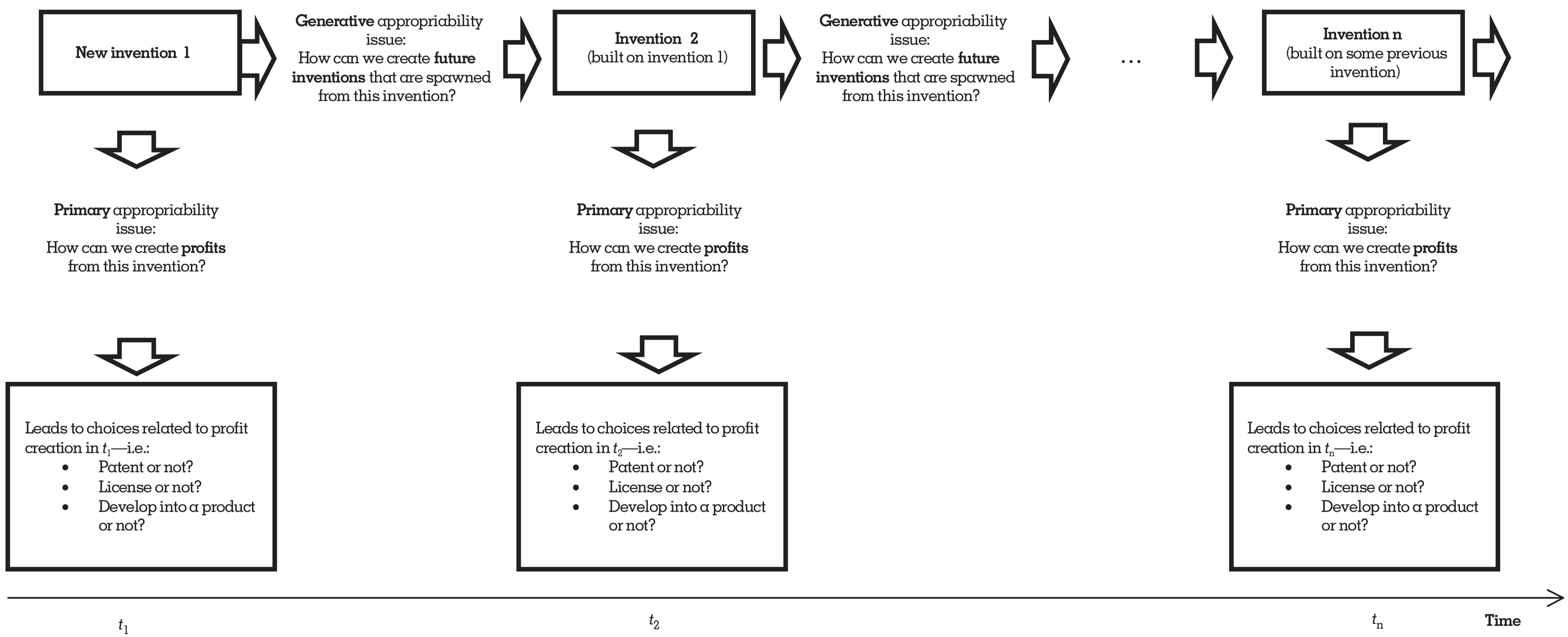
Consider Apple's invention of the iPod. In terms of PA, the iPod was an extremely successful product, generating significant profits for the company. However, Apple's GA performance is also notable. Apple took the iPod and combined the basic concept with a telecommunication function to create the iPhone. It also created a set of additional products, such as the iPod Nano, Shuffle, and so on, where it took the basic idea of the original iPod and developed new versions of products in which key attributes such as capacity, size, and weight were modified to fit the needs of users with different preferences. Subsequently, it took the basic concept of the iPhone (in itself a very successful product in terms of PA) and expanded its surface area and computing functions to create yet another new product, the iPad. PA and GA are thus two distinct outcomes reflecting two different aspects of a firm's invention performance.

To highlight the added value of GA as a construct, we note that building successfully on prior inventions is important for firms for multiple reasons. First, initial iterations of most inventions are relatively rudimentary. Subsequent versions improve significantly and often have far greater commercial viability than the original. Second, even when inventions become commercially viable, fully exploiting a firm's investments in research often entails being able to create subsequent generations of inventions that are increasingly differentiated for specific uses and market segments (e.g., iPod Nano, Shuffle) or that offer better price/performance values (McEvily & Chakravarthy, 2002; Roberts, 1999). Third, the most valuable application of a given invention is often not the application for which it was originally conceived. Coupling the conceptual kernel of an invention with new problems to be solved may then be extremely valuable (Hargadon & Sutton, 1997). For instance, Corning's Gorilla Glass product, now used very successfully for smartphone screens, is derived from a tough glass that was originally designed for use in car windshields. Simply put, then, firms need to care about GA to maximize the returns from their investments in knowledge and to safeguard against the possibility of being rendered obsolete by improved substitutes that build on their own prior efforts.

Multiple arguments also suggest that distinguishing between GA and PA is important. First, factors highlighted in the literature as enhancing appropriability, such as complexity, and causal ambiguity influence the two forms of ap-

[1] Although the GA concept could be expanded to nontechnological domains in that ideas from marketing or human resource practices could also be built on to create new ideas, to retain theoretical focus and clarity we limit the scope of our investigation to technological inventions.

FIGURE 1
Primary and Generative Appropriability



Imagine a firm that in Period 1 releases an Invention 1. At that time the firm faces a primary and a generative appropriability problem, the first being "How can we create **profits** from this invention?" and the second being "How can we create **future inventions** that are spawned from this invention?" If the firm successfully answers both questions, then in Period 1 it will earn a profit from Invention 1, but in Period 2 it will release an Invention 2 that builds on the concepts embodied in Invention 1. But once again the firm will have to think about (1) how to translate Invention 2 into a stream of financial returns through product embodiment or licensing and (2) how to build on the idea in Invention 2 in order to come up with Invention 3 in Period 3.

propriability differently, making it unlikely that the same managerial choices will maximize both forms of appropriability (see Table 1). Second, PA implies focusing immediately and directly on obtaining rents, whereas GA implies investing in creating a future opportunity for rents. Thus, the two forms of appropriability suggest very different (and potentially conflicting) foci for organizational resource allocation, systems, staffing, and attention. For instance, maximizing PA entails attention to commercialization concerns and requires focusing on the needs of a given set of existing users and optimally configuring the invention to those needs (Christensen, 1997; Christensen & Bower, 1996). In contrast, enhancing GA pushes attention toward inventiveness and requires thinking about how different groups of potential users might find the principle underlying the invention useful, or thinking about how that principle may be used to respond to other needs. Failing to explicitly recognize this trade-off and the accompanying distinctions may lead to a loss of competitive position. For instance, after its acquisition by News Corporation, Myspace significantly focused on realizing advertising revenue instead of allocating resources to develop improved products that incorporated features that could lead to an enhanced experience for the user. This choice was controversial within the company and even blamed for its decline, as competitors constantly upgraded and enhanced their offerings but Myspace did not (Gillette, 2011).

IDENTIFYING THE DETERMINANTS OF GA

The construct of GA has not been used in the literature before; however, in three streams of research, scholars have examined related concepts: (1) the RBV literature on threats from substitution and imitation (e.g., King, 2007; King & Zeithaml, 2001; McEvily & Chakravarthy, 2002), (2) the organizational learning literature on exploitation and reuse of knowledge (e.g., Fleming, 2001; Majchrzak, Cooper, & Neece, 2004), and (3) the economics literature on sequential invention (e.g., Hopenhayn, Llobet, & Mitchell, 2006). Table 2 presents an analysis of how GA and the constructs emerging from previous literature (imitation, substitution, exploitation, knowledge reuse, and sequential invention) are differentiated across multiple dimensions.

For any firm, GA is likely to be driven by two components: (1) the *cumulative invention component*, defined as firms' effectiveness in creating new inventions that build on their own existing inventions, and (2) the *preclusive component*, defined as firms' effectiveness in preventing others from building inventions based on the firms' inventions. The two components of GA can but do not necessarily covary. Firms can outperform on both components, underperform on both components, or perform well on one and poorly on the other. For instance, Xerox has created many inventions but has not necessarily been successful in building on many of them (Chesbrough, 2002) or in preventing others from doing so. As previously mentioned, Apple is an example of a firm that has managed to be creative in both building on its own inventions (e.g., the iPhone and iPad based on the iPod) and in precluding (or at least delaying) other companies from successfully building on its ideas (Burrows, 2009). Conversely, Epilady, the originator of pull epilators, is an example of a company that was high on the cumulative invention component of GA but low on the preclusive component (Geer, 1990).

Researchers in knowledge management and cognitive psychology have noted that breaking a concept into components and studying the components separately reduces the scope of the problem being analyzed and, thus, simplifies the search for identifying underlying relationships (Goldenberg, Mazursky, & Solomon, 1999). Using this approach, we distinguish between the cumulative and preclusive component of GA, identify determinants of the construct, and articulate propositions relating GA to these determinants. A key assumption we build on is that a firm's GA outcomes are likely to depend on access to and usage of the inventive knowledge of the firm. Enhancing the access and usage of the firm's inventive knowledge by inventors inside the firm and reducing the access and usage of the firm's knowledge by inventors outside the firm are then natural paths to enhancing GA.

We adopt a strategic, firm-based perspective. In uncovering the determinants of GA, we focus our attention on key levers that lie within the control of management and are commonly used to influence organizational outcomes: organization structure, organizational systems and processes, and organization strategy (Grant, 2007).

TABLE 1
Primary Appropriability versus Generative Appropriability

Key Comparison Dimensions	Primary Appropriability (PA)	Generative Appropriability (GA)
Domain of construct	Profits/economic rents (e.g., Teece, 1986): PA is defined in terms of the firm's share of *profits* from its inventions.	Ideas/inventions: The currency of GA is *ideas*; GA is defined in terms of the firm's share of the ideas or inventions that are spawned by its earlier inventions.
Relationship between construct and firm performance	PA influences the relationship between an invention and firm *financial* performance (i.e., revenues and profits earned by the firm). Only if the firm is able to translate the invention into a value proposition for a customer (be it another firm or the final consumer) can it commercialize the invention and create financial returns from it. However, PA is not directly related to firm *invention* performance (defined as the rate of inventions developed by the firm): a firm with a higher PA will appropriate a higher share of revenues and profits from each invention but will not necessarily come up with new inventions.	Conversely, GA (defined as the firm's success in building on its own prior inventions) influences firm *invention* performance by increasing the rate of inventions generated from the firm's prior inventions but may not be directly related to firm financial performance in the short run.
Possible measures	Profits from a new product; incremental profits made possible by new processes; licensing income from new products or processes	The proportion of inventions/products spawned by the focal firm's inventions that are created by the focal firm; of the total citations of the firm's patents, the proportion that come from the firm's own patents
Primary effect of patenting an invention	Generally increases PA for that invention, although the strength of the benefit varies in different industries, for different types of inventions (e.g., process versus products), and under different patent regimes (e.g., Cohen, Nelson, & Walsh, 2000; Levin, Klevorick, Nelson, & Winter, 1987; Teece, 1986)	May decrease GA because the doctrine of enabling disclosure enshrined in patent law makes building on the focal firm's inventions easier for others; patent law demands that patent disclosures should enable a person skilled in the art to create the claimed invention
Primary effect of keeping the invention secret	Generally increases PA, although the effect may vary across industries and contexts (e.g., Cohen et al., 2000; Levin et al., 1987; Teece, 1986); in a relative sense, though, in many contexts secrecy may leave the focal firm with weaker protection than patents—if competitors figure out how the invention works and the focal firm has not patented it, they could imitate it more easily	Improves GA—e.g., by diminishing the likelihood that somebody else will easily learn about the innards of a firm's new product or process
Primary effect of weak property rights	Reduces PA by reducing the inventor's ability to prevent imitation by enforcing property rights: competitors can more easily imitate the firm's extant inventions with a reduced risk of being sued (e.g., Teece, 1986)	Reduces GA by reducing the inventor's ability to prevent imitation by enforcing property rights: competitors can more easily build on the firm's extant inventions to generate new inventions with a reduced risk of being sued (effect of weak property rights is stronger on PA than on GA)

(Continued)

TABLE 1
(Continued)

Key Comparison Dimensions	Primary Appropriability (PA)	Generative Appropriability (GA)
Primary effect of complexity	Generally increases PA by making imitation difficult (because it increases the difficulty for the imitator to comprehend how the system works; McEvily & Chakravarthy, 2002)	Overall may not enhance GA because complexity may make building on inventions more difficult both from the inventor's and the competitors' perspectives
Primary effect of causal ambiguity	*Generally increases PA*: *Interfirm*, generally increases PA of inventor by making imitation difficult, since the potential imitator does not understand what and how to copy (e.g., King, 2007; Lippman & Rumelt, 1982; Reed & DeFillippi, 1990) *Intrafirm*, usually will not affect PA since the inventor can profit from its inventions even if it does not understand the internal linkages that led to the creation of the invention; where understanding the linkages in the causal process of inventing is necessary to the invention's commercial success, it could reduce PA	*May or may not increase GA*: *Interfirm*, enhances GA by making subsequent invention by competitors difficult, since the competitor may find it difficult to understand the innards of the focal firm's prior inventions *Intrafirm*, may reduce GA—e.g., by impeding the understanding of "the link between a competency and its performance outcomes" and by blocking the "ability to learn about and adapt that competency" (King, 2007: 168), which is required to build on prior inventions (e.g., King, 2007; McEvily, Das, & McCabe, 2000; Reed & DeFillippi, 1990)

We recognize that GA is likely to be driven by many additional factors, including context-specific and idiosyncratic factors such as the intrinsic fecundity potential and complexity inherent in a given invention, but we leave these to be identified by future work. Moreover, even within our chosen set of managerial levers, the list of predictors we identify is illustrative rather than exhaustive (see Table 3).

THE CUMULATIVE COMPONENT OF GA

GA and Nearly Decomposable Organization Structures

Enhancing cumulative invention requires that two goals be accomplished simultaneously—that is, that invention be enhanced within the firm and that the inventions generated build on prior ones. Organization structure, in particular the decentralization versus centralization pattern (Nickerson & Zenger, 2002) of research units within the organization, shapes the primary paths of information flow inside the firm (Siggelkow & Levinthal, 2003) and, thus, plays a key role in determining the extent to which the organization succeeds in cumulative invention.

Research activity in an organization can be conducted through multiple decentralized subgroups or units or through a single centralized one (Argyres & Silverman, 2004). From the perspective of enhancing invention and cumulativeness, these alternatives both imply a trade-off. Decentralized structures foster invention but hinder cumulativeness, whereas centralized structures foster cumulativeness but hinder invention. Decentralized structures—modular or fully decomposable in Simonian terms (Sanchez & Mahoney, 1996)—permit each subgroup to specialize in a limited domain of knowledge and become highly sensitive and responsive to needs in that domain (Nickerson & Zenger, 2002; Yayavaram & Ahuja, 2008). This depth of knowledge of the domain and the sensitivity to customer needs within that domain enhance thelikelihood of breaching the knowledge frontier, fostering invention (Katila & Ahuja, 2002). Yet decentralization hinders cumulativeness in invention. Decentralized structures provide inadequate coordination across subgroups (Nickerson & Zenger, 2002), since individual subgroups tend to be isolated from the creations and knowledge flow of other subgroups. Consequently, many potential inventions

TABLE 2
Construct Distinctiveness from Related Constructs

Construct/ Outcome	Definition of Construct	Is There a Second-Order "Invention" Required for the Construct to Be Meaningful?	Source of Second-Order Invention or Product	Scope of Application of Second-Order Invention	Source of Knowledge Built on in Second-Order Invention or Application (in case it is not an invention)	Perspective Adopted by Literature/Nature of Solution to Address the Problem	Illustrative Articles Highlighting the Construct
Generative appropriability (GA)	GA refers to a firm's effectiveness in capturing a share of the future inventions spawned by its existing inventions.	Yes—To obtain GA the original inventing firm has to create a new invention based on its earlier inventions.	Focal firm or other firms—If the focal firm is the source of the second-order invention and other firms have not been able to develop second-order inventions building on the focal firm's inventions, the focal firm has high GA. If other firms have successfully built on the focal firm's inventions, the focal firm has low GA.	Same market or different markets—The second-order invention could be a substitute for the focal product (e.g., an improved version of it), targeting the same market, or it could be a complementary or unrelated product targeting different markets.	Focal firm—For GA, the second-order invention builds on the concepts embodied in the focal firm's preceding inventions.	Focal firm's perspective—The focus is on firm-level solutions to the problem of GA. Suggested solutions to increase GA are the strategies outlined in the article, all of which are within the control of firms.	This article
Imitation	Refers to consciously associating elements common to the observable success of a given firm and replicating them (Alchian, 1950)	No—Imitation can occur when the second firm simply replicates the original invention. There is no requirement that an imitator build a new invention based on the original invention to talk about imitation.	Second-order invention is not required. Imitation is when a competitor replicates an existing product or service. No novel second-order invention is created.	Same market—In the context of imitation, the copy is targeted at the same market as the original invention.	Focal firm—To be called imitation, the copy needs to build on the focal firm's knowledge.	Focal firm's perspective—Causal ambiguity, complexity, scale, etc. are key mechanisms that protect the firm from imitation.	Dierickx & Cool (1990); King & Zeithaml (2001); Lippman & Rumelt (1982); Reed & DeFillippi (1990); Rivkin (2001); Teece (1986)

Substitution	Refers to the development of an invention functionally equivalent to the focal invention	Yes—Substitution occurs when an invention functionally recreates the product or service benefits of an existing invention. The author of the second-order invention is the substitutor.	Focal firms or other firms—The focal firm can itself come up with a substituting invention, or such an invention can be created by another firm.	Same market—In the context of substitution, the second invention is targeted at the same market as the original invention.	Focal firm or other firms—The substituting invention could be based on the knowledge of the focal firm that was the creator of the first invention or could be based on the knowledge of other firms.	Focal firm's perspective	McEvily & Chakravarthy (2002); McEvily, Das, & McCabe (2000)
Exploitation	Exploitation concerns the refinement and use of a firm's existing capabilities and knowledge bases, while exploration is related to the creation of new ones (Levinthal & March, 1981; March, 1991; Winter, 1971).	No—Exploitation may not involve invention at all. For instance, exploitation may entail expanding sales of an existing product from one geography to another.	Focal firm	Same market (e.g., Benner & Tushman, 2003; March, 1991), in general—Expanding to a different market may be considered exploration.	Focal firm—Exploitation implies using a firm's existing capabilities.	Focal firm's perspective	Benner & Tushman (2003); March (1991)
Knowledge reuse	Knowledge reuse refers to when knowledge acquired in one situation is applied to another situation (Majchrzak, Cooper, & Neece, 2004).	No—Knowledge could be reused in a different context without, necessarily, the creation of a new invention. For instance, a firm could use its routines developed from running an office in the United States to run an office in Europe.	Focal firm or others	Same or different market	No distinction made between the knowledge of the focal firm and that of others	Focal firm's perspective	Fleming (2001); Majchrzak et al. (2004); Murray & O'Mahony (2007).

(Continued)

TABLE 2
(Continued)

Construct/ Outcome	Definition of Construct	Is There a Second-Order "Invention" Required for the Construct to Be Meaningful?	Source of Second-Order Invention or Product	Scope of Application of Second-Order Invention	Source of Knowledge Built on in Second-Order Invention or Application (in case it is not an invention)	Perspective Adopted by Literature/Nature of Solution to Address the Problem	Illustrative Articles Highlighting the Construct
Sequential invention	Invention or derivative improvements based on an initial invention (Green & Scotchmer, 1995; Scotchmer & Green, 1990)	Yes—Without a succeeding invention that builds on the prior inventions, the construct is not meaningful.	Focal firm or other firms (Green & Scotchmer, 1995)—Either can be a source of inventions that build on prior inventions.	Same or different markets (Green & Scotchmer, 1995)—The literature often focuses on the same market.	Focal firm	Societal or public policy perspective—Solutions presented to the problem of sequential invention involve altering the design of the patent system in terms of breadth and length of patents—variables that are beyond the control of individual firms (Green & Scotchmer, 1995).	Green & Scotchmer (1995); Hopenhayn, Llobet, & Mitchell (2006); Scotchmer & Green (1990)

TABLE 3
Organizational Determinants of Generative Appropriability

Components of GA	Proposition
Cumulative component: Firms' effectiveness in creating new inventions that build on their own existing inventions	Proposition 1: The use of nearly decomposable organization structures for research leads to higher GA for firms.
	Proposition 2: The use of personalization-intensive approaches to knowledge management leads to higher GA for firms.
	Proposition 3: The use of incentive systems fostering stretch goals on invention, across-group collaboration, and joint problem solving leads to higher GA for firms.
	Proposition 4a: The use of time-paced creative processes leads to higher GA for firms.
	Proposition 4b: The use of semistructured creative processes leads to higher GA for firms.
	Proposition 5: Moderate levels of organizational resource availability for invention lead to higher GA for firms than very high or very low levels.
Preclusive component: Firms' effectiveness in preventing or precluding others from building inventions on the firms' inventions	Proposition 6a: Moderate dispersion of firms' research activities across geographic locations leads to higher GA for firms than very high or very low dispersion.
	Proposition 6b: The use of moderately sized research teams leads to higher GA for firms than the use of very large or very small research teams.
	Proposition 7: The use of retention-oriented HR practices leads to higher GA for firms.
	Proposition 8: Focusing inventive activity within a narrow domain or within closely related domains leads to higher GA for firms.
	Proposition 9: Owning a broader global infrastructure of supporting assets leads to higher GA for firms.
	Proposition 10a: Developing inventive knowledge through R&D alliances (as opposed to through in-house efforts) leads to lower GA for firms. This effect will strengthen as the number of R&D alliances increases.
	Proposition 10b: Forming link alliances leads to higher GA for firms than forming scale alliances.

that lie at the intersection of the knowledge bases of different subgroups and, hence, build on prior inventions are never created.

In contrast, centralized structures—nondecomposable in Simonian terms—foster building cumulatively on a firm's past inventions but may reduce inventiveness in the first place. In a centralized research structure, decision making and authority are concentrated at the central level (Argyres & Silverman, 2004), and decisions are not optimized for each subgroup (Siggelkow & Levinthal, 2003). Rather, subgroups coalesce around specific compromises and paths and then prefer not to depart from them to minimize organizational and political struggles, facilitating cumulation (Siggelkow & Levinthal, 2003). However, this stickiness around specific compromises reduces exploration, and that, together with the bureaucracy associated with centralization, leads to lower inventiveness (Nickerson & Zenger, 2002; Yayavaram & Ahuja, 2008).

One solution to the trade-off outlined above is provided by the creation of a small number of linkages between the subgroups of a decentralized research structure, in effect converting a decomposable structure into a nearly decomposable one (Sanchez & Mahoney, 1996; Simon, 1962). Such linkages could consist of internal consulting (Hargadon & Sutton, 1997), cross-group liaison teams (Fang, Lee, & Schilling, 2010), or shared senior management roles across subgroups (Tushman & O'Reilly, 2004). In a nearly decomposable structure, structural separation between the subgroups fosters the informational diversity and local application that give decentralization its power to develop inventions and exploit the opportunities in each local ecology. However, the few yet critical cross-subgroup linkages enable the transfer of knowledge from one subgroup to another, thereby fostering broad diffusion, assimilation, and reuse of the organization's inventive knowledge (Fang et al., 2010). These arguments suggest that nearly decomposable structures foster cumulative invention and, thus, enhance GA.

Proposition 1: The use of nearly decomposable organization structures for research leads to higher GA for firms.

GA and Knowledge Management Systems

The organization's knowledge management systems provide another path to bridge time and space and to transmit knowledge from the organization's past inventions to future potential users of that knowledge (Hollingshead, 2001; Lewis, Lange, & Gillis, 2005; Wegner, 1986). Knowledge management systems can facilitate cumulative invention by making knowledge of the firm's prior inventions more widely and easily accessible within the organization. Two broad formal approaches to knowledge management have been identified: codification and personalization (Hansen, Nohria, & Tierney, 1999). Although these approaches have been conceived in the context of organizational knowledge in general, they are also meaningful in the context of inventive knowledge and, hence, are useful for understanding GA.

We suggest that personalization-intensive knowledge systems will be more useful for the kind of information exchange required by cumulative invention than codification-intensive ones. Successfully using the knowledge from prior inventions to create new inventions often requires information-rich contextual detail (Hargadon & Sutton, 1997) or "metacontextual" information from the original invention (Majchrzak et al., 2004). Much information of this type tends to be tacit, socially embedded, and hard to codify (Hansen et al., 1999; Kogut & Zander, 1992). Codification and personalization approaches vary in their effectiveness in providing access to such tacit knowledge. We draw on Hansen and colleagues' (1999) rich description of these approaches to identify their key characteristics below and explore the implications of these characteristics for cumulative invention.

In codification, knowledge is classified using a people-to-documents approach. Information is extracted from the person who originally created it, converted into a knowledge object that is independent of the individual who created it, and stored in an electronic database, making the information available to all subsequent users in document form (Hansen et al., 1999). Conversely, personalization follows a person-to-person logic (Hansen et al., 1999). Although this approach also entails embedding basic elements of knowledge in electronic media, it emphasizes mechanisms for linking people to people rather than people to documents. This facilitates connections with the actual people who worked on the original project, enabling the transfer of noncodifiable, tacit knowledge through direct person-to-person contacts and enhancing cumulative invention.

In addition, each of these two approaches requires a set of complementary components (Hansen et al., 1999). In the codification approach, firms invest in skilled abstraction, codification staff, and sophisticated software for making connections between previously developed knowledge objects and currently faced problems. In the personalization approach, firms instead invest in a collegial and cooperative culture, enabling capabilities that foster activation of the person-person network connection (e.g., videoconferencing), and organizational processes, such as collective brainstorming sessions that are used to convert individual memories into organizational memories (Hansen et al., 1999; Sutton & Hargadon, 1996). Such culture facilitates exchange of prior knowledge and is therefore conducive to cumulative invention.

Although most organizations usually use both codification and personalization systems (Hansen et al., 1999), since the complementary investments required for the systems are different, most organizations tend to use one more intensively than the other. The prior arguments suggest that personalization-intensive knowledge systems facilitate cumulative invention and thereby enhance GA.

Proposition 2: The use of personalization-intensive approaches to knowledge management leads to higher GA for firms.

GA and Incentive Systems for Inventors

Three common mechanisms have been identified for controlling and incentivizing research personnel: (1) output control, which directs results and outcomes; (2) input control, which regulates what resources are used in the process; and (3) behavior control, which modulates the means leading up to the results (Cardinal, 2001). In the context of cumulative invention, all three matter. Specifically, precommitted stretch goals, collaboration across subgroups, and joint problem-solving behaviors are likely to foster higher levels of GA.

Under output control, reward systems incentivize the achievement of certain outcomes. Some organizations precommit to certain high invention output levels through publicly stated policies. For instance, 3M has a rule that 30 percent of sales must come from products launched in the last five years (Eisenhardt & Brown, 1998). This public pronouncement creates a strong motivation to invent; failure to successfully launch new products would imply both lowered financial rewards and a public loss of face. Further, the "stretch" nature of the goal implies that organizational members are likely to feel some pressure in delivering this outcome. Given the limited availability of time, the stretch goal is likely to encourage further evaluation of available knowledge that can be reused, as opposed to exploration of new knowledge (Majchrzak et al., 2004).

However, reusing knowledge for invention requires integration of familiar knowledge with at least some unfamiliar knowledge or perspective (Hargadon & Sutton, 1997; Majchrzak et al., 2004). This element of novelty can emerge from facilitating connections across different subgroups or units of the organization that have developed locally differentiated knowledge as they serve their own local contexts (Hansen et al., 1999). Input control systems that encourage collaboration between peers in different subgroups can provide the necessary novelty in knowledge inputs and cross-fertilization of the organization's existing knowledge to create new inventions based on past ones.

In addition, firms can foster behaviors that favor such internal cross-fertilization, which is conducive to cumulative invention. Incentivizing joint problem-solving behaviors implies that seeking help from others and providing help to others become not just legitimate but normatively desirable (Hargadon & Sutton, 1997). Help seeking and providing become perceived jointly as markers of the organization's solution-seeking orientation, in which solving the problem is more important than being seen as a self-sufficient, extremely intelligent individual (Hargadon, 1998). These arguments suggest that incentive systems fostering stretch goals, across-group collaboration, and joint problem-solving facilitate cumulative invention and, hence, enhance GA.

> *Proposition 3: The use of incentive systems fostering stretch goals on invention, across-group collaboration, and joint problem solving leads to higher GA for firms.*

GA and Creative Processes

Organizations enhance or diminish the ability of their members to deliver on outcomes through their design of organizational processes and routines (Brown & Eisenhardt, 1997; Eisenhardt & Brown, 1998; Sutton & Hargadon, 1996). We identify two types of organizational creative processes—time-paced and semistructured creative processes (Brown & Eisenhardt, 1997)—as facilitating higher GA.

Creative processes in organizations can be subjected to different types of temporal constraints. For instance, Brown and Eisenhardt (1997) and Eisenhardt and Brown (1998) described two distinct temporal approaches to launching new products: event paced and time paced. Event-paced launches are driven by external occurrences, such as competitive actions or market developments. In contrast, time-paced creative processes are driven by the calendar, with the organization following a rhythmic, time-paced approach (e.g., a new product launch every eighteen months).

Time-paced creative processes encourage cumulative invention and GA in multiple ways. First, they generate a constant time pressure for each invention (Brown & Eisenhardt, 1997). Frequent invention under these pressures suggests that the salience-in-memory of the organization's prior inventions will be higher: knowledge used in the recent past is likely to be recalled more easily. Further, the time pressure creates "a sense of urgency" and energy (Eisenhardt &

Brown, 1998) as each individual becomes conscious that his or her failure will hold up others. This enhances individual motivation to find a solution and, thus, leads to invention (Sheremata, 2000). Second, the use of an internal rhythm decouples the organization from the less controllable changes in the external environment while enhancing its sensitivity to technical changes within the organization (Brown & Eisenhardt, 1997). This reduced importance of external stimuli further encourages inventors to become cognizant of invention possibilities presented by the organization's own portfolio of past inventions. Third, the rhythm also makes possible a form of entrainment (Brown & Eisenhardt, 1997) as the various subgroups within the organization synchronize their activities to the same internal clock and even build on each other's inventions. For instance, Intel's introduction of a series of time-paced chips throughout the 1990s was probably enabled by the fact that in each case the firm was building on its own previous architecture and could rely on the manufacturing process for the ever-denser chips to be simultaneously coordinated.

Proposition 4a: The use of time-paced creative processes leads to higher GA for firms.

Creative processes in organizations also vary in their degree of formal structure. Highly structured creative processes that involve tight time accountability and costing, resource-gated procedures, and "disciplined problem solving" improve the efficiency of invention but may reduce its creativity (Brown & Eisenhardt, 1995; Clark & Fujimoto, 1991). In contrast, less structured creative processes enhance motivation and creativity (Amabile, 1987; Brown & Eisenhardt, 1997), which are beneficial to invention, but may lead to very scattershot invention outcomes rather than cumulative invention. Between these two is the possibility of what we call "semistructured creative processes" (see Brown & Eisenhardt, 1997, for the broader notion of semistructure), which we argue are likely to support high GA.

Semistructured creative processes foster cumulative invention by combining some structure with some freedom. They provide direction, but without explicit fiat, through "unobstrusive guidance" practices. For instance, policies providing a certain amount of time for inventors to pursue their own projects (e.g., 3M's 15 percent "personal" time) while restricting the bulk of their time to corporate projects, provide both corporate direction and individual autonomy. Such "personal" time fractions, while being substantive and thus motivating to inventors who value "freedom," may not be so high as to enable inventors to go on complete flights of fancy. Given that 85 percent of the scientist's time is occupied with corporate projects, it is likely that such "personal" time will be spent in the neighborhood of these existing corporate projects, for at least three reasons: (1) the human tendency of local search, (2) the constraint of scientists' expertise and attention being limited to specific areas, and (3) the social context that is likely to direct attention to commonly shared company-wide concerns. Similarly, providing a common subsidized cafeteria where all scientists eat (and thereby talk) or bringing together scientists from different units into company-wide invention fairs is a subtle way to encourage work along certain trajectories of knowledge that utilize the organization's earlier inventions. The above arguments suggest that using semistructured creative processes fosters cumulative invention and, thus, enhances GA for firms.

Proposition 4b: The use of semistructured creative processes leads to higher GA for firms.

GA and Resources Available for Invention

The amount of resources available to pursue the invention process is likely to influence the direction of inventive effort and, eventually, the firm's degree of GA. We suggest that moderate levels of resource availability should lead to higher GA, relative to very low or very high levels of resource availability.

Pursuing inventions is expensive and risky. For exploratory activity to be supported, sufficient resources need to be made available to the organization (Lounamaa & March, 1987; Nohria & Gulati, 1996). As resources for invention are increased from a very low level, inventive exploration is encouraged and inventiveness is enhanced. However, when the amount of resources made available for invention is very high, the incentives to examine and mine the firm's existing portfolio of inventions for new possibilities may be limited—exploration is fun and challenging, the money is available, and discipline is lacking (Nohria & Gulati, 1996). In contrast, moderate levels of resource availability permit some exploration but also encourage reuse of existing inventive knowledge as firms must make the most of what is available and adapt existing knowledge to address new problems (Majchrzak et al., 2004). These arguments suggest that cumulative invention and, therefore, GA will be curvilinearly related to the resources available for invention.

> *Proposition 5: Moderate levels of organizational resource availability for invention lead to higher GA for firms than very high* or *very low levels.*

THE PRECLUSIVE COMPONENT OF GA

GA and the Division of Inventive Labor

Hiring away scientists who embody a firm's inventive knowledge is a potent weapon in enabling a competitor to build on the firm's inventions. This is especially true in the context of tacit and hard to codify knowledge (Kogut & Zander, 1992). Task design can be used to mitigate such hazards (Liebeskind, 1996). The principles of division of labor and task design can be applied at two different levels within the organization to limit the degree to which information can leave the firm: first, to the division and distribution of tasks across geographic locations, and, second, to the design of individual jobs.

A firm can strategically limit the degree to which information can leave the firm by implementing a specific geographic distribution of research tasks across the organization (Zhao, 2006). Inventions create value through the synthesis of inventive knowledge elements with other complementary inventive knowledge elements or assets of the firm (Zhao, 2006). Individual knowledge elements are less valuable in the absence of their complementary components (Anand & Galetovic, 2004; Zhao, 2006). By effectively separating research projects into distinct and mutually complementary components, with each key component being based in a different geographic location, firms can make the act of recombination difficult for competitors. Successfully exploiting these knowledge elements to develop new inventions would require other firms to be able to tap into knowledge from multiple locations simultaneously, a task that is significantly more difficult than tapping into one location. Thus, firms can use the dual mechanisms of specialization (and differentiation) at the location level and integration at the organizational level to simultaneously enhance their inventive output while reducing the danger of knowledge expropriation (Demsetz, 1991; Grant, 1996).

Firms can also limit the degree to which information can leave by implementing a distribution of research tasks at the individual level through job design and employee conduct rules. Using larger project teams implies that individual scientists have a proportionately smaller role in the project. Such a division of labor ensures that the knowledge available with each individual member for each project is smaller. As a result, to reconstruct a given level of knowledge about a project at the original firm, the competitor must hire away more people (Ahuja, 2002). This is likely to be difficult. Further, with this arrangement the marginal product of each individual team member to a given project declines. Hence, to extract the maximal value from his or her own inventive knowledge, each scientist in the focal firm needs more complementary units of knowledge (from other scientists), thus making his or her departure decision more difficult. Finally, to the extent that some scientists do move, this task organization limits the disruption of the focal project since the lost scientists represent only a small part of the project's scientific expertise.

However, while the managerial choices of geographically dispersing research activities and enlarging the size of the resource team provide a fundamental impetus toward preclusion, these choices can also have a simultaneous implication for cumulative invention. Splitting research tasks across geographies raises integration and coordination challenges for the focal firm. Indeed, if tasks are extremely fragmented, these coordination challenges could interfere with the firm's own ability to invent, reducing GA. Similarly, as team size becomes very large, it is possible that the costs of integrating the knowledge to develop new inventions will increase and the coordination complexities will reduce inventiveness. Furthermore, with very large teams, the close ties that are necessary for the transfer of rich information between members may become more difficult to build and maintain, limiting the development of a social community. Such a social community is important since it can provide a superior work environment to foster the productivity of the team and serve as a retention device making it more difficult for individual inventors to leave (Paruchuri, Nerkar, & Hambrick, 2006).[2] These negative implications of the division of labor across locations or teams could limit the firm's own inventiveness and hurt its GA.

This suggests the existence of an inverted-U relationship between firms' division of inventive labor and their GA:

Proposition 6a: Moderate dispersion of firms' research activities across geographic locations leads to higher GA for firms than very high or very low dispersion.

Proposition 6b: The use of moderately sized research teams leads to higher GA for firms than the use of very large or very small research teams.

GA and Retention-Oriented HR Practices

In addition to being hired away by competitors, key inventors might leave the firm voluntarily to start their own companies. In this case a natural knowledge input for the inventive activity of the new-born enterprise would be the inventor's recent inventive knowledge, possibly originated within the context of the employer's inventive activity (Klepper & Sleeper, 2005). This suggests that a path to precluding other firms from building on the inventive knowledge of the focal firm is to reduce the turnover of research employees through retention-oriented HR practices. Moreover, retention also contributes to enhancing cumulative invention by ensuring that employees who developed earlier inventions stay within the firm and contribute their knowledge to later inventions. Common retention-oriented practices include higher relative pay, internal promotion opportunities, provision of employment security, and restrictions on employee activity, such as noncompete agreements.

Research on retention has emphasized that long-term incentives and inducements reduce a firm's turnover rate (Batt & Colvin, 2011; Doeringer & Piore, 1971). Such long-term incentives and inducements can help to enhance a firm's ability to preclude others from building on its inventions. For instance, higher relative pay increases the inventor's opportunity cost of leaving the firm. Similarly, noncompete agreements that prevent employees from working in areas that are close to the areas they worked in for their employer (Franco & Mitchell, 2008; Marx, Strumsky, & Fleming, 2009) also reduce the attractiveness of departure for employees, since they reduce employees' value to other employers and also significantly diminish employees' ability to work in their primary domains of expertise (Marx et al., 2009).

Long-term incentives and perceptions of job security also facilitate cumulative invention. For instance, delayed-vesting option compensation that provides employees with a right to buy shares of stock at set historical prices and hold them for a certain number of years inhibits departures and, hence, loss of knowledge to other firms. It also fosters cumulative invention by motivating inventors to continue inventing, since subsequent inventions represent both an exercise of their creative capabilities and a means of enhancing the value of their options. Further, such devices and long-term job security in general discourage inventors from extensively engaging in job searches (Direnzo & Greenhaus, 2011), facilitating the development of a longer-term research agenda within the organization, again fostering cumulative invention. The above arguments suggest that the use of retention-oriented HR practices fosters both preclusion and cumulative invention and, thus, enhances GA.

Proposition 7: The use of retention-oriented HR practices leads to higher GA for firms.

GA and Invention Domain

Whenever a firm commits resources to the development of a new invention, it faces a choice between building inventions in inventive knowledge domains that it is already active in or domains that are conceptually similar to the domains it is active in and building inventions in new or unrelated knowledge domains. Our argument draws on the literature on local

[2] We are grateful to an anonymous reviewer for this valuable suggestion.

search and absorptive capacity to predict that as a firm develops inventions in the same or related domains, its GA is enhanced as its ability to build on its inventions increases and the incentives and capability of competitors to build on its inventions decrease.

Understanding and knowledge are often cumulative (Cohen & Levinthal, 1990; Helfat, 1997; Nelson & Winter, 1982). The extent of a firm's prior experience in an inventive knowledge domain is, thus, a good predictor of the firm's subsequent invention success in that domain (Stuart & Podolny, 1996). Focusing inventive activities within a narrow domain or within closely related domains therefore fosters cumulative invention. Further, it is also likely to favor preclusion of other firms. Entry into a knowledge domain where the focal firm has been inventing extensively is likely to be unattractive to competitors, because as a firm progressively expands its dominance in a specific domain, its greater experience in the domain increases its relative competence (Cohen & Levinthal, 1989, 1990; Lane, Koka, & Pathak, 2006) vis-à-vis other firms. Recognizing this relative disadvantage, and given the finite carrying capacity of any domain, when faced with a firm who dominates a given knowledge domain, potential entrants will choose to forgo entry into that domain and to seek other domains where their disadvantage is not as pronounced. The above arguments suggest that focusing inventive activities within a narrow domain or within closely related domains fosters both cumulative invention and preclusion and, thus, enhances GA.

> *Proposition 8: Focusing inventive activity within a narrow domain or within closely related domains leads to higher GA for firms.*

GA and Supporting Assets

Firms can also influence the incentives of competitors to build on their inventions through ownership of the supporting assets necessary to commercialize the stream of inventions. Manufacturing facilities, marketing and sales forces, and a global infrastructure to commercialize an invention are all critical for profiting from inventions in general (Teece, 1986). We emphasize that such assets also retain their value in the context of GA. An established global infrastructure can create a speed advantage for the firm that owns the infrastructure by enabling the translation of a given invention into a marketed product or service across the globe in an efficient and effective fashion. This speed advantage is useful for converting a given invention to profits and also acts as a deterrent to other competitors who want to enter that invention niche with derivative inventions.

Consider two firms, A and B. Assume that A has an infrastructure of supporting assets in twenty countries, whereas B has such an infrastructure in only two countries. Now consider firm C, which is considering building on an inventive opportunity opened up by the inventions of either firm A or B. Other things being equal, firm C would prefer to build on the opportunity created by B's inventions rather than on the opportunity created by A's inventions. The concern for C would be that if it launched a new derivative invention based on A's inventions, A could replicate C's efforts and launch a similar product relatively quickly in the twenty markets in which A is currently active. Yet, if C picks B's ideas to build on, it knows that B's speed advantage exists in only two markets. Therefore, other things being equal, C would face less competition if it picked B's ideas over A's to build on. Based on the above arguments, we suggest that a broader global infrastructure fosters preclusion of other firms and, thus, enhances GA.

> *Proposition 9: Owning a broader global infrastructure of supporting assets leads to higher GA for firms.*

GA and R&D Alliances

Firms often generate inventive knowledge through R&D alliances with other firms. We argue here that this choice of mode for sourcing inventive knowledge has implications for firms' GA. Specifically, developing inventive knowledge internally enhances GA more than developing it through joint research projects with other firms. First, in-house development limits outsiders' access to the firm's knowledge. In contrast, joint knowledge development efforts with other firms imply that the focal firm risks exposing its knowledge core (Thompson, 1967) to its partners, who may then use that knowledge to build on its inventions (Garcia-Canal, Valdes-Llaneza, & Sanchez-Lorda, 2008; Hamel, Doz, &

Prahalad, 1989). Second, in-house development allows firms to make idiosyncratic inventive choices relating to the design and creation of the product or process such that their choices are maximally and uniquely complementary only with their own bundle of activities and prior inventions (Anand & Galetovic, 2004). This, in turn, limits the opportunity for other firms to use this knowledge in an effective fashion.

Although, in principle, having many alliances could also provide an opportunity for the focal firm to benefit from more knowledge spillover opportunities, it is likely that this effect may not play a significant role in increasing its GA. With many alliances being enacted simultaneously, given finite absorptive capacity, the firm's ability to assimilate and absorb knowledge flows may be diminished (Burt, 1992). Further, controlling knowledge flows in alliance settings requires tight compartmentalization of individual alliances and tight definition of alliance scope (Khanna, Gulati, & Nohria, 1998; Oxley & Wada, 2010). With many alliances, such tight control may be difficult. Indeed, in such a context knowledge may leak from many different points of a firm in a sprinkler head fashion (Owen-Smith & Powell, 2004), facilitating the inventive efforts of others. The above arguments suggest that developing inventive knowledge through R&D alliances reduces the preclusion of other firms from building on the focal firm's inventions and, thus, reduces GA, an outcome further worsened by having many alliances.

> *Proposition 10a: Developing inventive knowledge through R&D alliances (as opposed to through in-house efforts) leads to lower GA for firms. This effect will strengthen as the number of R&D alliances increases.*

When firms do use alliances to develop inventive knowledge, different types of alliances have differing effects on GA; specifically, scale alliances entail higher risks to GA than link alliances. A scale alliance involves two partners that both bring the same capability into the alliance, with the core objective of facilitating economies of scale (Dussauge, Garrette, & Mitchell, 2004). Thus, Intel and AMD's forming a relationship to develop a new microprocessor would be an illustration of a scale R&D alliance, since both firms bring chip development skills to the alliance. Conversely, in a link alliance the partners bring different skills to the alliance (Dussauge et al., 2004), as in the case of research collaboration between a chip design company and a chip manufacturing foundry.

Two sets of arguments suggest that the leakage of inventive knowledge to outsiders is likely to be worse for scale alliances than for link alliances. First, given the similarity in their competence backgrounds, partners in scale R&D alliances are likely to have high levels of absorptive capacity for the knowledge of their partners (Cohen & Levinthal, 1989; Lane & Lubatkin, 1998; Park & Russo, 1996). Commonalities of interests and competencies between firms in scale alliances (Ahuja, 2000; Dussauge et al., 2004; Koka & Prescott, 2002; Lane & Lubatkin, 1998) facilitate information diffusion, and as the number of such ties increases, policing them for diffusion of information may become progressively more difficult. In R&D link alliances, instead, partners bring different kinds of knowledge to the alliance and may not have as strong an absorptive capacity for their partners' knowledge as they did with scale alliances.

Second, unlike scale alliances, which imply a horizontal relationship between partners, link alliances reflect vertical ties. The overlap between the interests of partners in link alliances is lower than that in horizontal ties. Many of the aspects of a firm's inventive knowledge core and the trajectories of inventions that are possible from it may be of limited interest to the partners. For example, a chip foundry firm in an alliance with a chip design firm may have limited interest in understanding how higher-order features can be designed into chips—its interest would be more in creating new ways of manufacturing the chips than in new product features per se. These arguments suggest that forming link alliances fosters the preclusion of other firms from building on the focal firm's inventions, relative to scale alliances, and, thus, enhances GA.

> *Proposition 10b: Forming link alliances leads to higher GA for firms than forming scale alliances.*

DISCUSSION AND CONCLUSIONS

In this article we drew a distinction between two notions of appropriability and identified some of the determinants of the less studied one.

We developed the concept of GA as a potentially relevant outcome in assessing the performance of inventive firms. We identified two paths to influencing this outcome—cumulative invention and preclusion of others—and developed propositions to explain how firms could use basic levers of organizational structure, systems, and strategy to enhance the firm's GA. In this section we suggest directions for further research based on the identification of caveats to be considered in the context of GA, and we discuss the managerial and theoretical implications of GA.

Implications for Future Research on GA

We have indicated several reasons why firms might want to enhance GA, and we also have identified strategies firms may use to do so. However, an issue worth considering is whether it makes sense for firms to always try to enhance GA. It is indeed likely that, as with other performance outcomes for firms, enhancing GA may be more or less desirable depending on underlying conditions. We identify several sets of circumstances under which firms would have to evaluate trade-offs before deciding whether or not to enhance GA. For instance, the value of enhancing GA may depend on expectations about the nature of the spawned inventions. Spawned inventions could be *substitutes* (they address the same buyer need and render the original invention less competitive), *complements to the existing invention* (they boost the sales of the original invention), or *inventions unrelated to the existing invention* in product-market terms. Prima facie, it would appear that firms may have different attitudes toward the importance of increasing GA depending on whether the expected subsequent inventions are substitutes versus complements.

Other trade-offs may emerge because of conflicts between GA and other desirable outcomes for a firm. We noted earlier that the strategies to enhance appropriability may be different across PA and GA, thus leading to a conflict between the two. Similarly, different environments may cause the relative importance of PA and GA to vary. For instance, in an environment of ferment, where new competitive products are continuously being launched (Abernathy & Utterback, 1978), being able to develop newer, enhanced products may be more important than trying to figure out how to marginally improve the monetization of a given invention. However, in other environments the relative payoff between PA and GA may be reversed. Developing a "contingent hierarchy of appropriabilities" and identifying the conditions under which a particular form of appropriability is favored over the other would indeed be an exciting and useful research direction.[3]

Trade-offs are also associated with the two components of GA: cumulative invention and preclusion of others. For instance, cumulative invention is likely to foster relatively speedy invention since building on existing inventive knowledge enables the firm to respond faster than entering a knowledge space de novo. This could be advantageous in the short run and in dynamic environments where speed is important. However, such a strategy may also be a source of rigidity in the long run. A firm focused on building on its existing inventive knowledge may not adequately experiment with new inventive trajectories and may end up not aligned with the needs of consumers. Similarly, precluding others from building on the firm's inventions provides the focal firm dominance in a knowledge domain. However, since great solutions can emerge from the cross-fertilization of different and unrelated inventive knowledge bases, knowledge spillovers from one firm to another may open new paths to invention and possibly even new inventive fields. These potential benefits are at risk when the firm pursues preclusion very strongly.

Evaluating GA performance gives firms a chance to draw managerial attention to a set of counterfactuals that are not commonly focused on in performance reviews. Much performance measurement in firms focuses on evaluations of managers and organizations through their realized outcomes on certain milestones, such as profits. However, a case could be made that optimizing performance may entail examining not just how well a firm has performed but also how much better it could have performed. GA provides an outcome that draws attention to this aspect of performance. An organization tracking its GA may recognize not only how successful it has been in commercializing a product but also

[3] We are grateful to an anonymous reviewer for suggesting the development of a hierarchy of appropriabilities.

how much more could have been possible by recognizing and exploiting follow-on inventions. This discussion suggests that identifying potential measures of GA would help to push the GA research agenda as well as its usage in practice. In industries where patents are meaningful, patent data can be used to measure GA. Citations in a patent are markers of its intellectual lineage, since they indicate that a particular invention was built upon a prior invention. A simple archival measure of GA is provided by the ratio of self-citations to a firm's patents to the total citations received by the firm's patents. In other contexts one could imagine using product characteristics and features data to trace linkages between products within and across firms.

Implications for Theory

Priem and Butler (2001) have noted that specifically identifying "how" resources create sustained value and incorporating a temporal component that relates a firm's history to its current outcomes are two key issues that need to be addressed for further development of the RBV. This article addresses these issues. The construct of GA draws attention to the possibility that sustained value creation occurs not just through the "defense" plays of protection from imitation and substitution, already well discussed in the literature, but also through a third path, the "offense" play of creating new inventions that lead into new product markets. Further, by identifying specific strategies through which firms may leverage the power of their past inventions into future inventions, this article also illuminates a temporal link between an organization's past successes and its current outcomes and shows how resources, instead of simply being eroded over time (Priem & Butler, 2001), may also lead to new rents. For instance, Apple's performance over the last decade has in some part been based on protection from imitation and substitution in existing product markets. Yet perhaps equally important is its performance in creating new inventions building on its own prior inventions, which has helped Apple to target completely new product markets.

This article also identifies implications for the literature on organizational learning. Much of the knowledge literature has focused on the identification of factors that enhance interorganizational learning and facilitate knowledge transfer across organizations (Grandori & Kogut, 2002). GA draws attention to two less studied aspects of organizational learning. First, GA emphasizes how a firm can enhance the utilization of its own existing knowledge over time for the purposes of invention. A distinguishing characteristic of knowledge is that, unlike physical inputs, it is not consumed in its usage in the production process. Rather, usage may make prior knowledge even more useful by indicating different ways that it can be recombined (cf. our discussion of the *conceptual* component of an invention). Yet converting this potential for reuse—which is one of knowledge's most promising and productive features—from being latent to becoming realized requires a better understanding of how organizations might systematically improve their utilization of their existing knowledge. Although knowledge recombination is recognized as one of the core functions of a firm (Grant, 1996), there has been limited research on the strategies that enable firms to recombine their knowledge into new syntheses, a notable underemphasis in the context of an increasingly knowledge-driven economy.

In this article we focus directly on the knowledge reuse problem and, in the process, highlight an important puzzle: knowledge is valuable because it can be reused, but it is difficult to store or retrieve in a manner that makes it available at the locus where its reuse would be the most beneficial. The propositions we have presented identify how elements of organizational structure, systems, and strategy can be used to address this puzzle in the context of knowledge reuse for invention. Identifying other strategies that can be used to address this puzzle and targeting knowledge reuse contexts beyond invention are natural directions for further research.

Second, the learning literature has commonly focused on how organizations can increase their learning from other organizations. In contrast, this article draws attention to the strategies that firms may use to *prevent* others from learning from them. Although prima facie that appears socially undesirable, a nuanced consideration draws our attention to the incentive problem underlying GA—in a for-profit world, activities that do not yield returns to the actor are eventually not undertaken. In that sense, the strategies reflected here, while appearing undesirable, may still be better than the alternatives in promoting research effort. Theoretically, this article therefore represents a call to integrate more directly the consideration of incentives and competition into the literature on learning (Grandori & Kogut, 2002). For instance, research modeling knowledge spillovers would need to explicitly recognize that firms could strategically be attempting to minimize such spillovers. This may imply a need for a more nuanced theoretical and methodological approach in studying how organizations learn from each other.

Understanding how the two components of GA (and the managerial choices underlying them) might interrelate with each other would be helpful—another task for future research.

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