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PERSPECTIVE

Exploring the Foundations of Cumulative Innovation: Implications for Organization Science

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Organizational theorists have built a deep understanding of the conditions affecting knowledge sharing. However, for innovation to occur, knowledge must not just be shared, but also reused, recombined, and accumulated. Such accumulation is not inherent to the innovation process but can be either supported or limited by the context in which it occurs. We propose a framework arguing that three conditions shape this context: disclosure, access, and rewards. We show how these conditions operate at the institutional, field, community, and organizational levels. Our framework highlights how when innovators encounter barriers to the accumulation of knowledge, their solutions are often organizational ones rather than legal ones. This suggests an expanding terrain for organizational scholars interested in debates often dominated by law and economics.

Key words: innovation; intellectual property; ideas; cumulative

> How to enable entrepreneurs to appropriate the fruits of their investments in cumulative and sequential innovation without impeding follow-on innovation and without creating barriers to entry has become one of the great unsolved puzzles that the law and economics of intellectual property rights needs to address as the new millennium gets under way. (Reichman 2001, p. 23)

Introduction

Reichman's research agenda highlights the growing importance of cumulative innovation—the process of building on the ideas of others to create new innovations. This phenomenon lies at the heart of creativity, organizational success, and economic growth (Romer 1990, 1994; Hargadon and Sutton 1997; Aghion and Howitt 1998). However, we do not fully understand the conditions that shape an innovator's actual ability to build on the work of others. Therefore, Reichman's challenge cannot, as he suggests, be left to law and economics alone. Organization scholars need a place at this table. For it is only through a synthesis of economic, legal, and organizational perspectives that we will deepen our understanding of the conditions that affect the degree to which innovation can and will be cumulative.

In their studies of cumulative innovation, economists and legal scholars have privileged the effects of legal institutions, such as intellectual property rights, on innovators and follow-on innovators (Nelson 1986; Scotchmer 1991, 1996, 2004; Dasgupta and David 1994). However, legal institutions do not operate in isolation. Institutions, fields, organizations, and communities operate in concert, often in the shadow of the law, to establish mechanisms enabling or inhibiting knowledge accumulation (Hargardon and Douglas 2001, O'Mahony 2003, Murray 2006). For example, organizational scholars have shown how innovators rely on social relationships to tap diverse networks and communities to build on the ideas of others (e.g., Weick 1979, Hargadon and Sutton 1997, Fleming 2001, Reagans and Zuckerman 2001). By further elaborating the conditions affecting cumulative innovation, we encourage organizational scholars to examine how intellectual property rights affect innovation, bring the law into our understanding of organizational life, and build a more comprehensive understanding of the innovation process. To do this, organizational scholars must shift their emphasis from studies of *knowledge flows* to examining the opportunities and constraints innovators confront as they attempt to reuse, recombine, and accumulate knowledge. Therefore, the overarching question we encourage organization scholars to investigate is: *How do the conditions surrounding the access and use of an innovation affect others' ability to innovate cumulatively*?

In this essay, we develop an analytic framework to address this question. Our framework synthesizes economics and organization theory to identify three conditions necessary for people to innovate cumulatively—disclosure, accessibility, and reward. In their most simplified formulation these three interrelated conditions provide follow-on innovators with the minimally sufficient requirements to build on the innovations of earlier generations. We also identify the level of analysis where these conditions are established. With economic and organization theory as a guide, we draw on examples from several sectors and argue that the antecedents for cumulative innovation are established across multiple levels of analysis: institutional, field, organizational, and community. We then use this framework to motivate a long-term research agenda.

This framework helps organizational theorists contribute to the cumulative innovation conversation in three ways. First, it moves the discussion beyond a narrow focus on the legal system to encompass social and normative mechanisms that may affect knowledge accumulation. Second, it explicates the interplay among institutions, fields, organizations, and communities in providing the conditions that shape an innovator's ability to innovate cumulatively. Third, this framework also improves our ability to compare knowledge-accumulation processes in different settings. These contributions should enhance our ability to develop more generalizable theories of cumulative innovation.

Traditional Perspectives on Knowledge Accumulation

Scholars have long recognized that when we innovate, we stand on the shoulders of others (Merton 1973). Recent evidence shows that innovation is, more often than not, cumulative to the extent it incorporates prior knowledge from multiple sources (e.g., Fleming 2001, Katila and Ahuja 2002, Garud and Karnoe 2003). Such an emphasis on cumulative innovation may, at first glance, seem at odds with the more traditional focus on the disruptive nature of innovation (Christensen 1997). However, in assessing the conditions that affect the degree to which an innovation is accumulative, we make no claim as to its ability to be disruptive. An innovation that accumulates disparate contributions from different sources may be as disruptive as an innovation that builds on a narrow stream of prior innovations and vice versa. The relationship between patterns of knowledge accumulation and the degree to which an innovation is disruptive remains an open question. However, the cumulative innovation framework proposed in this paper provides a starting point for scholars interested in these issues.

Our argument is simple. If our economy is increasingly reliant on the production, refinement, and accumulation of ideas (Powell and Snellman 2004), then it is essential that we understand not just what affects flows of knowledge and ideas, but also what affects the degree to which innovators are able to recombine and integrate these ideas with extant stocks of knowledge. However, with little exchange between economics and organization theory, we have only a fragmented picture of the accumulation process. To develop a framework that enhances our understanding of the conditions for cumulative innovation, we draw from both literatures.

Organizational theory highlights one important aspect of knowledge accumulation—the role of networks and technical communities in helping innovators to build on one another's ideas (e.g., Van de Ven 1993, Hansen 1999, Hargadon and Sutton 1997, Fleming 2001, Knorr-Cetina 1999). A large body of work illustrates the importance of an individual's or firm's network position in providing opportunities for knowledge accumulation through brokerage and by facilitating knowledge exchange. Different network structures can support innovation (Hansen et al. 2005): Brokered networks arising when an individual or organization connects otherwise disconnected innovators can be effective for the accumulation of previously diverse knowledge (Burt 2004). Cohesive collaborations can also lead to creative outcomes (Uzzi and Spiro 2005).

The identification of such networks as critical to an innovator's success has directed scholarly attention to the conditions shaping knowledge flows. Hargadon and Sutton argue that knowledge brokers use their industry position to facilitate the acquisition, retention, and retrieval of information (Hargadon and Sutton 1997, p. 717). The ability of brokers, such as IDEO, to gain access to a variety of ideas enables them to effectively recombine knowledge (1997, p. 723). Access is enhanced by innovation work practices that reinforce the benefits of such a structural position. Designers of IDEO engage with artifacts (Latour 1987), become immersed in prior knowledge, and "learn by using" (Rosenberg 1982). Artifacts help them recall and recombine distinct pieces of knowledge offering a tangible form of access to help translate knowledge from one community of experts to another (Bechky 2003a, b; Carlile 2004).

Organizational scholars studying open-source communities also examine conditions that allow for knowledge accumulation without necessarily labeling them as such. Although open-source communities may lack many of the institutions that reinforce academic norms, they are strongly influenced by programming norms embracing access to code and reciprocal exchange of ideas (Stallman 1999, Levy 1984, von Hippel and von Krogh 2003). Like academics, open-source contributors tend to be motivated more by recognition than reward (Lakhani and Wolf 2005). But motivation for recognition is not enough to spur contributions. It is only with open access to a community's source code and development process that contributors can make accumulative contributions (Shah 2005, von Krogh et al. 2003, Lakhani and von Hippel 2003). However, little research has examined how differences in the norms and structures of particular communities actually affect opportunities for knowledge accumulation.

Economists, in contrast, explicitly attend to the factors affecting cumulative innovation but with a strong emphasis on the law—specifically intellectual property rights (Scotchmer 1991, Jaffe and Lerner 2004). The patent system is designed to manage the tension between rewarding first-generation innovators while ensuring that second-generation innovators can learn of ideas generated by others and have adequate incentives to build on them. To understand this tension economists model how changes in the length and scope of patent protection shape incentives for both first- and second-generation innovators (Scotchmer 2004, Katz and Shapiro 1985, Klemperer 1990). Empirical studies explore how changes in patent law influence the rate and direction of knowledge accumulation using comprehensive patent statistics (Hall and Ziedonis 2001, Hall et al. 2001). Economists also examine how different organizational settings (Henderson et al. 1998), promotion systems (Henderson and Cockburn 1994), and reward structures (Lach and Schankerman 2006) affect the accumulation of patented knowledge.

Dasgupta and David (1994) provide a richer institutional perspective on the economics of knowledge accumulation. Their comparative institution-level analysis identifies two conditions—the disclosure of ideas and rewards for disclosure—that support cumulative innovation. These conditions exist in both public and private institutions—although they are provided through quite different mechanisms. The private system depends on contractual and legal mechanisms to provide disclosure and rewards. The public system depends on social and normative mechanisms.

The public system is based on the premise that knowledge should be accessible and widely distributed with limited constraints on an actor's ability to reuse or recombine it. Thus, knowledge accumulation depends on norms that foster disclosure, verification, and diffusion of knowledge. These norms are most commonly associated with science (Merton 1973) and encourage individuals to disclose their findings through a variety of (often reputational) incentives. In contrast, innovation in the private system relies on institution-level legal mechanisms structured around the provision of private property rights (Nelson 1959, Arrow 1962). Governments have made disclosure a condition for patent awards. Innovators must disclose the knowledge needed to allow others to replicate the work. In return, innovators receive rights allowing them to exclude others from accessing or using the invention for a limited time.

Economics provides an institution-level understanding of cumulative innovation with parsimonious models. However, the dominant mechanism theorized to shape cumulative innovation is the blunt and costly instrument of the law. Even when other instruments are considered, such as technical committees (Simcoe 2006), economists tend to ignore how social and organizational factors mediate the use and effectiveness of legal tools (e.g., Gilson 1999, Saxenian 1996). In contrast, organization theorists devote attention to knowledge sharing rather than knowledge accumulation. Their emphasis has been on how social factors affect flows of knowledge (Allen 1977, Hansen 1999). But for innovation to occur, knowledge must not just flow: Innovators must have the ability to *actually* combine or accumulate knowledge.

A Framework for Examining Cumulative Innovation

We synthesize contributions from economic and organizational theory to provide a coherent framework for the study of cumulative innovation. Our framework is particularly important, given recent changes in our economy. First, the degree to which innovations are cumulative may be increasing (Fleming and Sorensen 2003). Second, with a shift toward "open innovation" (Chesbrough 2003), contributors to innovations are more likely to come from different types of organizations (e.g., Powell et al. 1996, Owen-Smith and Powell 2003) and across individual and firm units of analysis (Rosenkopf et al. 2001). Third, with a growing diversity of contributors to cumulative innovation, the potential for divergent interests also rises (e.g., David 2003, Nelson 2004). Recent debates over the role of IPR across the academic-industry divide or among content providers and distributors in the entertainment industry illustrate these tensions.

However, scholars provide few systematic insights to illuminate these debates. Such insights can only come when we recognize that the accumulation of knowledge is not inherent to the innovation process but can be either supported or limited by the context in which innovation occurs (Mokyr 2004). When we acknowledge that cumulative innovation is essentially a behavioral process, then the conditions affecting one's ability to recombine knowledge become of interest. Rather than focusing on "who knows who," the cumulative innovation framework focuses on "who is able to share, reuse, and build on knowledge" and, most importantly, "under what conditions." This approach will help organizational scholars contribute more systematically to policy and industry debates. It can also open up new avenues for organizational scholarship.

The framework is built by articulating the *antecedents of cumulative innovation*—conditions fostering or inhibiting the accumulation of "pieces" of knowledge at multiple levels of analysis.

Antecedents of Cumulative Innovation

Economists emphasize disclosure and reward as important antecedent conditions for knowledge accumulation—conditions they assume operate at the institutional level. Organizational theorists emphasize access to knowledge as the central condition for accumulation—operating primarily at the community or network level. By integrating these two approaches, we identify three minimally sufficient conditions for cumulative innovation: disclosure, access, and reward. It is only with mechanisms for disclosure, opportunities for access, and rewards to encourage disclosure and access that today's innovators can build on the work of earlier generations and innovate cumulatively.

First, to cumulatively build on the ideas that "came before," the innovator must know what came before; this requires *disclosure* on the part of prior generations. Disclosure is the first step, initiating a cycle that allows for cumulative innovation (e.g., Dasgupta and David 1994). It makes knowledge available to other innovators (for free or for a price) but does not necessarily provide access rights to that innovation or the capability to reuse it or modify it. Disclosure is therefore a necessary condition to innovate cumulatively, but alone, it is insufficient.

Second, the innovator must be able to *access* these ideas. We distinguish disclosure from access because to build on the knowledge disclosed by someone else one must understand *how* the original knowledge was developed and have access to the various inputs (tools, materials, information, techniques). The mere act of disclosure does not specify the terms under which follow-on innovators can engage in two distinctive activities: (1) explore, understand, and practice the ideas and (2) build on and combine the idea into a new innovation. We define these two types of access because each constrains or enables second-generation innovators in fundamental ways. *Reuse access*, which grants "reuse rights" and allows others to experiment with how those ideas were developed. *Recombinative access*, provides permission to not only reuse ideas but to recombine them in the creation of a new innovation.

Third, both of these conditions depend on *rewards,* to encourage earlier innovators to both disclose their ideas and provide access so that later generations can usefully integrate these ideas. We refer not only remunerative rewards, but also reciprocal rewards such as reputation or credit (Latour and Woolgar 1979).

We recognize that a wide range of entities affect the degree to which the antecedent conditions for knowledge accumulation are provided. These range from "high-level" entities such as legal bodies, whose edicts are broadly applicable to most innovators, to local expectations and practices relevant to only a few. As an organizing framework, we focus on how these conditions arise at four levels of analysis: institutions, fields, communities, and firms.

At the highest level we examine how institutions have a wide-reaching influence on innovators engaged in cumulative work. We then analyze the more specific influence of fields on innovation (which we define as "those organizations that, in the aggregate, constitute a recognized area of institutional life" (DiMaggio and Powell 1983)). Our next level is the community—a group of interdependent participants who provide the context in which learning about innovation occurs (Brown and Duguid 2001). Such communities may operate within the boundaries of a firm (Brown and Duguid 1991) or across firms and other organizations in scientific (Knorr-Cetina 1999), technical (Barley 1986), or occupational (van Maanen and Barley 1984) communities. Finally, we articulate the role of organizations in shaping the conditions for knowledge accumulation. Although innovators within firms may be composed of many distinctive communities and subject to field-level influences, the firm itself, through geography (Allen 1977), processes (Hargadon and Sutton 1997), or policies (i.e., nondisclosure agreements) shapes the antecedent conditions for innovation.

Many empirical examples suggest that institutions, fields, communities, and organizations constitute a comprehensive list of entities that shape the conditions for cumulative innovation. Next, we provide a more fine-grained analysis of how the three antecedent conditions for knowledge accumulation are either facilitated or constrained at these different levels.

Disclosure

Anyone who discloses ideas or knowledge does so to make it available to others but without necessarily providing them access. Innovators disclose their ideas through a range of mechanisms (e.g., patents, publications, community forums, individual conversations) that are facilitated or constrained at multiple levels of analysis. With selected examples, we explore how different disclosure mechanisms affect how follow-on innovators build on ideas.

Institutions. In the private sphere, patent law shapes disclosure by requiring innovators to disclose their ideas at a level of detail sufficient to "allow one skilled in the art" to replicate their claims. However, the degree to which disclosure allows for "enablement" is sometimes a source of contention. In the United States, tests of enablement are often enforced by overworked and understaffed federal patent examiners (Jaffe and Lerner

2004, p. 142). The only action open to a follow-on innovator who has difficulty replicating ideas in patents is through the courts—which can be slow and costly.

In the public sphere, disclosure is supported at the broad institution-level by academic publishing. Like patents, journal articles must provide disclosure of methods and results. However, academic communities vary in their expectations for disclosure in publishing. Most if not all journals use peers to determine the veracity and detail of disclosure through the review process, rather than using professional examiners. Another critical distinction lies in the nature of the sanctions involved for poor (or false) disclosure. Unlike the patent system, journals can only provide relatively informal sanctions (leaving the punishment for falsification up to the employer) (Couzin and Unger 2006).

Both private (legal) and public (academic) institution-level arrangements for disclosure make knowledge available to all. Although acquiring a full understanding of any disclosed knowledge may require years of training and analysis, the "source" information from which to do so is available. First-generation innovators can choose to disclose in either public or private institutions, if their knowledge is deemed worthy of publication by peer reviewers or worthy of patent grant by examiners. Second-generation innovators can also choose the degree to which they build on knowledge disclosed in either form (although there may be associated access costs). However, the degree to which an individual's community or organization rewards either behavior may affect the disclosure choice (Owen-Smith 2003, Stern 2004). In the life sciences, innovators in academia and industry may pursue dual routes of disclosure—simultaneously filing patent applications when an idea is disclosed in an academic publication. These "patent-paper" pairs disclose knowledge in two distinctive settings offering similar levels of disclosure but (as we will discuss below) quite different implications for access (Murray 2002, Murray and Stern 2007).

Fields. Actual disclosure practices within fields can profoundly affect the ability of an innovator to build on the work of others. Surveys have shown firms' use of patents may be differentiated by industry sector, producing widely varying levels of knowledge disclosure (Levin et al. 1985). In different fields, firms, their suppliers, and key partners established distinctive practices for knowledge disclosure. For example, in response to the Federal Trade Commission's actions against Dell in 1996, standard-setting bodies now require the disclosure of knowledge otherwise unavailable, particularly when it is needed to practice a new standard. These choices can affect the entire set of actors within a particular field. After the U.S. Supreme Court granted strong patent coverage of genetically modified organisms, firms began disclosing ideas and materials previously secret, in the hopes of receiving patents.

In the arts, culture, and entertainment fields, innovators have collaborated to change (and often expand) disclosure. Creative Commons, for example, developed a common set of reuse and distribution terms, which artists can use to license their works with more flexibility than copyright can offer (Lessig 2004). Their modular license allows creators to decide whether and how to restrict the ability of others to use or recombine original works for commercial or noncommercial purposes. Approximately 145 million works licensed under Creative Commons' terms (Rohter 2007) have arguably enhanced the ability of creators and innovators within common fields to disclose their work to others. However, as is the case with all these examples, the ultimate effect of field-level changes in disclosure practices on cumulative innovation remains undocumented and unmeasured.

Organizations. Organizations face complex strategic decisions regarding what, where, and when to disclose knowledge throughout their innovation process. Internal policies and practices may affect the degree to which individual members of an organization disclose their ideas to outsiders. At a minimum, managers must assess the value of disclosure as a source of motivation and reward for employees (Stern 2004). More strategically, they must balance their desire for secrecy with the benefits of disclosure. Some of these benefits include reciprocity—the opportunity to learn from others working on similar problems (Saxenian 1996); reputation—the value placed by investors on peer-reviewed publications or a patent portfolio (Hall et al. 2005); exchange—for example, cross-licensing; and direct rewards—from property rights (Grindley and Teece 1997). These challenges are not new. Increasingly, however, firms are establishing new disclosure practices that improve the conditions for cumulative innovation.

For example, after investing millions researching the genetic origins of type 2 diabetes, Swiss pharmaceutical firm Novartis released on the Internet, for anyone to use, a vast amount of gene sequence data from a genome-wide analysis of more than 3,000 type 2 diabetes patients. The president of the Novartis Institute for Biomedical Research chose this strategy because the data contained more research leads than his researchers could ever pursue: "To translate this study's provocative identification of diabetes-related genes into the invention of new medicines will require a global effort" (Tapscott and Williams 2007). Novartis has not created specific mechanisms to capture the value of any cumulative innovations that stem from their disclosure. Although Novartis' three-year lead in analyzing the data prior to release is likely to confer some advantage, the firm has created valuable goodwill and reputational benefits with the research community.

Novartis is not alone in its strategic use of disclosure. Bar-Gill and Parchomovsky (2003) identified more than

1,000 firms engaged in publicly disclosing their research and development (R&D) findings (a practice referred to as defensive publishing). This practice provides disclosure to potential follow-on innovators and prevents others from establishing ownership over these ideas using patents. Such practices also allow firms to signal their openness to enable innovators to build on existing ideas and may encourage complementary innovations.

Communities. Formal disclosure practices only partially describe "disclosure-in-action" because communities also shape the nature and effectiveness of these practices. For example, the timing and scope of disclosure varies significantly across different academic communities. Until the early 1990s, knowledge of newly discovered gene sequences was disclosed in academic journals—but the time delay from discovery to disclosure was discretionary. This delay allowed human geneticists to keep their knowledge of new gene sequences secret while they (or their students) hunted for the more precise location of a gene. With the entry of a private sector gene-sequencing effort (Celera), the academic community strove to justify the role of public funding for gene sequencing. In 1996, as part of their commitment to public sequencing, leading scientists in the community created the Bermuda Rules—a new set of disclosure practices requiring scientists to disclose their gene sequences within 24 hours into Genbank (a public DNA database).

There is no systematic evidence documenting whether this shift in disclosure changed the rate of knowledge accumulation, but anecdotal evidence suggests the new policy, combined with new DNA search infrastructure, allowed scientists from around the world to compare sequences, combine disparate data, and accumulate knowledge at a greater rate. Thus, a community's practices and rules has dramatic consequences for follow-on innovation rates.

The degree to which disclosure practices affect cumulative innovation is also mediated by the role of tacit knowledge. As scholars have articulated, "full" and "meaningful" disclosure may require more than simply a "text." For knowledge to be actionable, it may require access to materials, know-how, translation, or the sharing of expertise among individuals. This type of disclosure most often arises within communities through informal mechanisms (Collins 1974, Brown and Duguid 1991, Bechky 2003a, Carlile 2004).

In scholarly, technical, occupational, and online communities, disclosure enhances or restricts according to a community's norms or rules. Reciprocal exchange norms among academic colleagues (Crane 1969) or coworkers (Saxenian 1996, Almeida and Kogut 1999) encourages disclosure. For example, the revolutionary elucidation of the structure of DNA in 1953 by Watson and Crick would not have been possible without the informal disclosure of the X-ray crystallography results by Franklin, Wilkins, and Gosling at a small meeting at University College, London, in July 1951 (Berressem 2005). Similarly, members of open-source software communities and user-innovation communities share norms that encourage the disclosure of problems, inquiries, and suggestions to foster individual and collective learning (Lakhani and von Hippel 2003). In contrast, formal contracts such as nondisclosure agreements (NDAs) constrain individuals from disclosing organizational secrets in communities—although their enforcement varies by region (Marx et al. 2007). Thus, an individual's dual membership in communities and organizations (e.g., Van Maanen and Barley 1984) may result in conflicting norms and rules regarding disclosure. For example, when industrial scientists want to publish their research, they may find the scope or timing of such disclosures limited by the strategic imperative of their employers. How such conflicts are resolved, and the consequences for knowledge accumulation remain to be explored.

Access

To cumulatively build on the knowledge disclosed by someone else requires access. By managing both reuse and recombination access, early generations of innovators control the use of their ideas by later generations. Innovators exert control over access to their ideas using legal, normative, or technical mechanisms operating at institution, field, organization, and community levels.

Institutions. Patent law mandates one type of disclosure and academic publishing another, yet there are few overarching institutions (legal or otherwise) that support access to the innovative work of prior generations. Patents give innovators the right to provide, restrict, or prohibit access to follow-on innovators under whatever terms and conditions they deem acceptable. There are two exceptions to these broad rights. First, "march-in" rights allow federal agencies to insist patented ideas developed with federal funding be licensed to others under certain conditions (such as where public health is at stake or the innovations are not in use). Second, an innovator's "refusal to license" may constitute an antitrust violation and be subject to federal review (Lewis and Yao 1995, Mackie-Mason 2002).

However, the U.S. Congress recently gave greater attention to the issue of access to innovations. A new law shaping access in technical fields is the Digital Millennium Copyright Act. It permits both technical and legal means to restrict reuse and recombinative access (Samuelson 2001, Felten 2002, Samuelson and Scotchmer 2002). Hardware can be engineered to restrict follow-on innovators from accessing copyrighted content—limiting reuse access. The act reinforces this barrier through legal means by restricting follow-on innovators from reengineering or bypassing technical barriers. Samuelson (2001) and Felten (2002) have persuasively argued that restricting an owner's right to experiment with technology they have purchased hampers learning and innovation. However, copyright owners depend on this law to prevent unauthorized tampering of content that enables copyright violation.

National resources such as the Library of Congress and the Smithsonian Institution preserve and disclose the work of primary generations of innovators, but they do not provide access to these ideas for later reuse and recombination. Immediate access through university libraries is often costly and restricted. This may be why some members of Congress recently drafted a Research Public Access Act (S. 2695),[1] which would require federally funded research to be made publicly and freely available online within six months of publication. Although this bill would only apply to federally funded research (some 65,000 publications per year from the National Institutes of Health (NIH) alone), it has received the ire of academic journals and publishers who view it as reducing their ability to recoup costs. About 10% of academic journals currently make their publications freely accessible to the general public (Dotinga 2007). Other private organizations took the initiative to improve access to the research they fund. For example, the Howard Hughes Medical Institute (HHMI) is paying the Elsevier publishing house to make HHMI funded research available to the public for free after six months (Dotinga 2007). Thus, at the institution level, new laws are being both proposed and passed either restricting or enabling access to knowledge and innovation—with only a limited appreciation of their cumulative effects.

Fields. Innovators within specific fields, particularly dynamic ones, are experimenting with access rules to foster (or stifle) cumulative innovation by follow-on innovators. Preliminary evidence suggests changes in access rules significantly affect subsequent rates of knowledge accumulation within fields.

In the field of cancer biology, changes in access to one of the first cancer "animal models" (animals engineered with a predisposition to a disease)—the "Oncomouse"—affected many different innovators. When the Oncomouse discovery was published by Harvard scientists in 1984, it was widely recognized as an important building block for further innovations in cancer biology and drug discovery. Access to the mice followed the broad norms of public science (Merton 1973) and the local conventions of mouse geneticists (Rader 2004). Research collaborations among scientists initially formed the basis of exchange, but over the years, mice started to be shared through informal agreements (Murray 2006). Industrial scientists were also able to access the mice through a mix of informal and formal means. As a result, knowledge accumulation proceeded rapidly.

In 1988, access rules changed. Harvard University was granted a patent on the Oncomouse, which, under the terms of its research grant, was exclusively licensed to DuPont. The corporation imposed strict access conditions on all follow-on innovators. It limited recombinative access through reach-through rights to any downstream use of the Oncomouse. It also controlled reuse access by charging for the mice (with differential prices for academic and industry innovators) and requiring oversight of publications by follow-on innovators. The private sector found the access costs prohibitive, and the use of Oncomice in drug discovery slowed and failed to reach its full potential. Academic research was inhibited as follow-on innovators turned to different animal models. By the late 1990s, DuPont, at the behest of the NIH, eased its access requirements on academic scientists, and knowledge accumulation by academics rose again. In its agreement with NIH, DuPont publicly recognized the importance of access to furthering cumulative innovation and stated it "deeply appreciates the importance of wide dissemination of tools for basic research and is committed to making [Oncomouse] available to the academic community" (quoted in Marshall 2000).

Within information technology fields, access to technology is similarly contested (and strategically used), particularly in markets dominated by a single technology platform. Technology platforms provide both an architecture that facilitates interactions among component parts as well as a set of rules that govern access to those parts or interfaces by others (Eisenmann et al. 2006, Gawer and Cusumano 2002, Baldwin and Clark 2000). Such platforms can be designed and owned by a single player in a field (e.g., Microsoft owns Windows) or by multiple parties (e.g., many players contribute to the Symbian telecommunications platform). Similarly, innovators within a field may cooperatively establish or revise rules of access to shared technologies or standards by working through alliances or technical standard committees (Rosenkopf et al. 2001, Simcoe 2006).

Because platforms affect the rules by which many in a specific technical field must play, some countries, such as France, now view access to proprietary platforms as critical to their national interests. They are concerned that proprietary platforms may inhibit competition and encourage the development of "winner-takes-all" markets (e.g., Eisenmann et al. 2006). The French government has thus mandated access to proprietary platforms (such as Apple's iTunes software) with the aim of creating a level playing field and furthering opportunities for cumulative innovation.[2] Other European Union nations are equally concerned. Thus, although rules of access to a particular technology may appear to be squarely the purview of a single firm or actors within a common field, they can gravitate to the national or even transnational level when the interests of many are perceived to be at stake. As we show in the next section, organization-level practices also play an important role in managing access among different generators of innovators.

Organizations. It remains an organization's strategic decision to provide others access to internally developed innovations, platforms, technologies, or other types of knowledge (e.g., Garud and Kumaraswamy 1993). The patent system mandates disclosure, but *access* to patented innovations is typically negotiated at the organizational level (less frequently at the inventor level). Armed with a patent, a firm selectively contracts with any party interested in incorporating their ideas into their own activities on an exclusive or non-exclusive basis (Edwards et al. 2003). Exclusive licenses offer great benefit to a single party but can also narrow the number of possible paths following from an innovation. This makes the ultimate effect of such licensing arrangements on cumulative innovation difficult to evaluate. In either case, follow-on innovators must bargain with early innovators to access their ideas through legal mechanisms (Scotchmer 2004).

Such organizational strategies extend well beyond patented knowledge. As research on Intel, Microsoft, Palm, Cisco (Gawer and Cusumano 2002), and Sun Microsystems (Garud and Kumaraswamy 1993, Garud et al. 2002) shows, "platform leaders" may provide selective access to parts of their technologies (often managed through common interfaces) to allow other firms to develop complementary innovations. This allows innovators to tightly manage reuse and recombinative access in ways that enable their competitive advantage over those who would otherwise be able to generate follow-on innovations. The impact of a single organization's access decisions on the rate and direction of follow-on cumulative innovation within markets or fields is not fully appreciated. Often these choices are examined in terms of the strategic benefits to the focal firm or its competitors, as exemplified by the U.S. Supreme Court's lengthy and costly analysis of the consequences of Microsoft's closed operating system on its competitors.[3]

However, we know when a firm makes new access choices, it often affects other firms in the field. When IBM committed to share access to 500 software patents with the open-source community,[4] firms such as Novell, Sun Microsystems, and Computer Associates soon followed suit. These firms have since created a patent commons (http://www.patentcommons.org) to aggregate their commitments to share patents. Unlike patent pools, there are no shared royalties, and use of their content is not restricted to members but open to the public. Such "boundary organizations" (typically nonprofit foundations) (O'Mahony and Bechky 2007) play a new role in managing access to once privately held bodies of knowledge. They provide a safe "trading zone," where actors organize around their shared interests in cumulative innovation without compromising their divergent interests. Examples from both biology and open-source software suggest that boundary organizations can have a positive impact on cumulative innovation—by preserving access to knowledge and innovations and by enabling innovators from public and private spheres to work cumulatively.

For example, biological resource centers (BRCs) serve as repositories for critical materials used in the life sciences by both industry and academic scientists. Individual scientists, firms, universities, and nonprofit laboratories use more than 300 BRCs worldwide to deposit and distribute biological materials critical to basic research. Some academic journals even require that authors use BRCs. According to U.S. patent law, the deposition of critical materials (particularly biological materials) is required if the materials are not publicly available through simple experimentation (35 USC114) (Stern 2004). Furman and Stern (2006) use careful comparisons to examine the effect of BRC cell line storage and distribution on later knowledge accumulation. They find that after deposit of the cell line, scientific articles receive higher rates of citation than those that do not (Furman and Stern 2006). They conclude that BRCs have the power to amplify the impact of scientific discoveries by enhancing the ability of future generations to access past discoveries. Across a wide range of technical arenas, new boundary organizations serve a similar function—they maintain access to common bodies of knowledge enabling parties from both public and private sectors to innovative cumulatively. The prevalence of such organizations, their effectiveness and their origins are less clear.

Conversely, organizations may have an unintended negative effect on future cumulative innovation. A recent study of the semiconductor industry showed when firms exit specific product markets and cease to engage in R&D, citations to the firms' patents decline markedly (Hoetker and Agrawal 2007). The loss of access to private knowledge embedded in individual or community practices may inhibit other firms from building on those innovations.

Communities. Communities also shape access to the innovations they generate. Perhaps the best known setting for community-level action is the open-source software movement. Open-source code provides reuse access because an informed reader of the source code understands how it can be modified. However, the *right* to modify code and accumulate ideas embedded in it requires recombinative access of a legal nature. The Gnu General Public License (GPL) is probably the most widespread example of such a license and is used throughout the open-source community (Lerner and Tirole 2005, O'Mahony 2003). This legal mechanism reinforces norms of reciprocity by mandating the reciprocal disclosure of source code for derived works (Rosen 2005). Few would disagree that open source licenses helped spur new practices in the software industry, but the ultimate effect of access on the ability to innovate cumulatively in either public or private sectors has not been measured.

Reward

Last, for cumulative innovation to occur, innovators need assurance of some form of reward, encouraging them to disclose their ideas and provide access to others. Such rewards may be intrinsic but can also include remunerative or reciprocal rewards from follow-on innovators. A system that allows for a flow of rewards between first- and second-generation innovators is necessary but without some ease in distributing rewards among different generations, innovators will have difficulty accumulating knowledge (Scotchmer 1991). Evidence suggests rewards can be managed through normative or legal mechanisms at multiple levels.

Institutions. Legal mechanisms typically support institution-level arrangements for rewards across innovators. However, the degree to which patents bring economic rewards depends on the scope of the patent, and on the competitive landscape of the industry (Teece 1986). Moreover, even within sectors, the rewards realized from patents are highly skewed (Scherer 2001, Scherer and Harhoff 2000). This explains first-generation innovators' preference for a broad patent scope. Unable to predict which innovation will be the most valuable to others down the road, innovators prefer to accrue as much leverage or bargaining power as they can when establishing early property rights (Jaffe and Lerner 2004). Some argue that overly broad patent protection reduces the incentives of second-generation innovators, particularly in areas relying on multiple prior pieces of knowledge, such as biotechnology. As Heller and Eisenberg noted, "Each upstream patent allows its owner to setup another tollbooth on the road to product development, adding to the cost and slowing the pace of downstream biomedical innovation" (1998, pp. 698–9). Jaffe and Lerner (2004) argue that changes in U.S. legal institutions are increasingly supportive of intellectual property holders' scope and duration over time. As a result, innovators in a common field seek to use negotiation and/or collaboration as an alternative mechanism for distributing rewards.

Fields. Different types of actors within a field may collaborate to forge field-level solutions for reward allocation across generations of innovators. For example, patent pools help reduce intellectual property transaction costs among parties with interdependent or cumulative innovation components (Merges 2001). Multiple patent holders aggregate their patents and agree to make them available to other members. The pool may agree to license rights to nonmembers and distribute the proceeds. Both legal and organizational means are used to ensure a reciprocal flow of rewards among parties to the same innovation arena. Copyright collectives work in a similar way; they bundle and manage the distribution of rights to large quantities of work that may be held by multiple parties (e.g., the American Society of Composers, Authors, and Publishers) (Merges 2001). These solutions, however, received more attention from legal scholars than from organizational scholars. Thus, their ultimate effect on the rates and direction of cumulative innovation is underexplored.

As an alternative to organized collective action, innovators use bilateral licensing agreements and contracts to craft the distribution of rewards to follow-on innovators, as reflected in royalty rates, up-front payments, and milestone payments (Anton and Yao 2002). However, researchers only recently began to explore the consequences of different contractual structures on future cumulative innovation.

Organizations. Within organizations, rewards affect an innovator's willingness to disclose and provide access to his or her knowledge as well as his or her willingness to build on prior knowledge. These rewards are shaped by the norms of particular work groups or communities inside the organization (Knorr-Cetina 1999, Brown and Duguid 2000, Bechky 2003a). Community norms are either reinforced or countered by organizational policies and practices that structure rewards. For example, Hargadon and Bechky's research (2006) shows that even when disclosure and access was rewarded by a professional service firm, concern for personal power and fiefdom could still trump and lead to secrecy. Furthermore, organizations tend to vary in the degree to which formal reward policies and practices align with their strategies. Henderson and Cockburn (1994) found that pharmaceutical firms exhibit wide variation in the degree they reward the disclosure of research findings in academic peer-reviewed journals through promotion, salary enhancement, and recognition.

When an organization's formal structure fails to provide adequate rewards for cumulative innovation, innovation is stifled—even when disclosure and access are provided. A case in point is the Apache http Web server, developed at the National Center for Supercomputing Applications (NCSA). Apache is a software program that accepts http requests from a Web browser and "serves" a Web page to the requester. The NCSA made its source code freely available, and when commercial use of the Internet grew, demand for the program increased. Developers around the world began sending code improvements to the NCSA. However, no one at the NCSA accumulated these improvements into future versions of the code base.

Although the NCSA provided both disclosure and access by placing the Apache source code in the public domain, it failed to reward or encourage cumulative innovation at a critical time. In response, eight developers accumulated improvements to the code themselves and formed a community—"the Apache" group

(Fielding 1999). The group built a revamped code base and protected it with an "Apache" license that permits free modification and reuse of the code as long as the community is attributed (Rosen 2005). Without organizational incentives or legal requirements, *norms* of reciprocity prevailed—hundreds of contributors donated bug fixes and system enhancements from the time of the project's inception (Mockus et al. 2002). The Apache server is now used by more than two-thirds of the 80 million websites surveyed.[5]

Years later, the group incorporated as a nonprofit organization (Apache Software Foundation or ASF) and now provides organizational and legal support to more than 30 open-source projects (O'Mahony 2005). Additionally, the ASF helped further a host of follow-on innovations derived from the Apache code in both public and private sectors. Like the boundary organizations discussed earlier, the ASF reinforces reciprocal rewards among innovators and has become an organizational platform for cumulative innovation—supporting an entire industry selling Apache related goods and services. This example suggests that a community can become an effective locus for fostering cumulative innovation when an organization fails to do so. It also suggests that we should study the transition of innovations between communities and organizations. CERN's transition of the governance of the World Wide Web to the W3C consortium hosted by the Massachusetts Institute of Technology is one example. IBM's transition of the Eclipse application development platform to a nonprofit foundation is another. What triggers such transitions and the consequences for cumulative innovation is yet to be elaborated.

Communities. The role of communities in shaping the rewards for knowledge accumulation is not new. For centuries, collaborators in academic communities have disclosed and provided access to knowledge, techniques, and materials in return for shared recognition through citations and career-based rewards of promotion and tenure. Similarly, contributors to open-source software communities allow their work to be freely used, modified, and distributed in return for recognition by their peers and the prestige of contributing to the community (von Krogh et al. 2003).

However, in this case, community norms do not operate alone—they are blended with software licenses and organizational structures that reinforce a reciprocal flow of rewards (such as the ASF). At a minimum, open-source software licenses require appropriate attribution to the community (Rosen 2005). At a maximum, licenses such as the Gnu GPL request follow-on innovators to freely distribute the source code of any derived works they disclose. Gnu does not constrain an innovator's ability to derive rewards from his or her reuse of GPL code, but it does limit those seeking to acquire exclusive rights to derived works. While the community collectively monitors the reuse of open-source code and may use cease and desist letters, their primary enforcement mechanism is the normative threat of public opinion (O'Mahony 2003).

Strengths of the Cumulative Perspective

This essay began by posing the question *How do the conditions and rules surrounding an innovation affect others' ability to build cumulatively upon that innovation.* To answer this question, we drew on organizational theory and economics elaborating the antecedent conditions for knowledge accumulation: disclosure, access, and reward. These conditions are shaped at four levels of analysis: institutions, fields, organizations, and communities. Our framework allows organization theorists to specify how these conditions are created, how they are enacted, and how they subsequently shape the ability of others to innovate cumulatively. It also achieves three other objectives.

First, it provides a more coherent approach to the identification of factors enabling or inhibiting knowledge accumulation. In contrast to innovation approaches describing the source, dispersion, or location of innovation e.g., "distributed" or "open" innovation (Chesbrough 2003, von Hippel 2005), we attend to the legal and social context and mechanisms affecting who can share and under what conditions. These two approaches are not mutually exclusive; rather, they have a different emphasis.

Second, by specifying the antecedent conditions for cumulative innovation, we are better equipped to consider the different ways actors shape the innovation process at multiple levels of analysis in a conceptually consistent way. Studies of knowledge networks often focus on individuals (e.g., Hansen 1999, 2002) and economic analyses focus on broad institutional conditions (Dasgupta and David 1994, Murray and Stern 2007). Our framework considers how parties at multiple levels work together to enable (or stifle) the accumulation of knowledge. This brings us closer to understanding how knowledge accumulation is enabled "on the ground" and suggests a way to understand the interplay of institutions and daily practices on knowledge accumulation. Davis and Marquis (2005) argue that this approach is particularly helpful in explaining *how* macro level shifts affect actors (e.g., Lounsbury and Ventresca 2002).

Our intent is not to provide a framework to adjudicate the degree to which a particular innovation is or is not cumulative. Nor will it allow us to assess whether an idea has the intrinsic potential to serve as a foundation for future innovations. Our approach is agnostic as to whether an innovation is incremental or radical in nature. Instead, it allows us to analyze any and all types of innovation because each can contribute to cumulative innovation. Incremental and radical innovation will likely differ in the diversity and origins of the knowledge they incorporate, but accumulation processes are at work in both instances. The degree to which the rate and diversity of knowledge accumulation are disruptive to specific industries needs to be explored. In fact, considering the antecedents of innovation might help distinguish incremental innovations from radical ones.

Finally, our framework is particularly well suited, but not limited to, knowledge-intensive fields with a distributed "locus of innovation" (Powell et al. 1996) such as software, biotechnology, and creative industries. As scholars increasingly recognize that sources of innovation are more diverse and more distributed in sectors such as semiconductors, oil and gas exploration, consumer products, and electronics the scope of our framework widens (von Hippel 1988, Chesbrough 2003, Jeppersen and Frederiksen 2006, Linder et al. 2003).

New Research Directions

Our framework drives a rich research agenda for organization scholars—working alone or in collaboration with those in law and economics. The need is clear for more empirical studies examining how changes in disclosure, access, and rewards affect follow-on accumulation. At the same time, we must study how organizations grapple with the opportunities and challenges of knowledge accumulation within or across organizational boundaries. This essay raises many interdisciplinary questions, but we focus on two dimensions: (1) ways to advance organizational theory with more systematic analysis of cumulative innovation within and across organizations and (2) ways to sharpen our toolbox by improving the measures, methods, and approaches used to study cumulative innovation.

Advancing Organizational Theory. First, we encourage more systematic analysis of organizational decisions affecting the subsequent rate and direction of cumulative innovation. From a strategy perspective, we must develop a clearer understanding of the *types of knowledge* firms are willing to disclose or access and *when*. At what point in the innovation cycle are firms more likely to pursue an innovation strategy based on making their ideas available for follow-on innovators? And when do they strike a more complex balance of access and restriction? How do these decisions vary by type of innovation? At first glance it might seem all knowledge accumulation is beneficial for a firm. But we might well ask what levels of follow-on knowledge accumulation are actually desired. Does this affect an organization's policies and practices? The answer is most likely contingent. The degree of disclosure and access may well depend on the type of innovation itself or the structure of the industry (e.g., Tushman and Rosenkopf 1992, Baldwin and Clark 2000).

Future research should examine how disclosure, access, and reward decisions affect opportunities for follow-on innovations. It must move beyond sparse economic models that consider only patents and the sharing of monetary rewards (Scotchmer 2004) by accounting for how rewards of all types for the next generation of innovators are balanced with potential losses for the firm. For example, scholars might examine how firms benefit from the reciprocity, learning, and reputation coming from making their innovators widely available.

These decisions cannot be evaluated in a vacuum, as firms simultaneously use institution-, field-, organization- and community-level practices selectively and strategically to either foster or stifle knowledge accumulation. For example, IBM is one of the top patent filers and also the largest corporate supporter and developer of open-source software (e.g., Baldwin et al. 2003). Simultaneous pursuit of such divergent approaches suggests that a firm's strategies for disclosure and access differ across its portfolio of innovations. However, we know little about what contributes to these differences. Thus, we should compare how different mechanisms support different levels of knowledge accumulation within a firm. What types of mechanisms are used? To date, organizational theory has paid little attention to the role of law, while economic studies tend to neglect the impact of norms. We suggest scholars integrate the use of legal mechanisms into organizational theory and examine how laws are shaped by the local conditions in which they are employed (e.g., Knorr-Cetina 1999).

Second, how do an organization's internal policies affect the provision of the three conditions necessary for knowledge accumulation inside the organization? Individual innovators need the appropriate incentives to participate in cumulative innovation. Firm policies and resources determines whether people can discover and access the knowledge they find around them. Current studies in knowledge management focus on building repositories of information. We argue that disclosure without reuse or recombinative access may be insufficient to foster cumulative innovation. A cumulative innovation perspective would broaden this approach to address issues of disclosure, access, and reward. Do all users have access, and are they aware of access restrictions (such as NDAs, patents, etc.)? Are there rewards for the accumulation of knowledge from outside the firm? In an effort to enhance their rates of cumulative innovation, companies like Proctor and Gamble explicitly reward reuse and recombination of knowledge developed outside the firm (Huston and Sakkab 2006).

Third, what of the tensions arising within the firm among researchers, product managers, strategists, and lawyers in setting strategies that blend legal and social mechanisms? A firm's legal counsel needs to play a significant role in shaping the mechanisms through which a firm participates in cumulative innovation. Doing so effectively requires a deep understanding of how intellectual property rights are used to protect a firm's assets, and how the allocation of rights can affect downstream innovation—inside as well as outside the firm. Moreover, the decision to pursue intellectual property rights and how to triage them requires an appreciation for the social practices associated with the relevant innovation communities. Such choices can benefit from the integration of complex technical and legal considerations or what Bagley recently called "legal astuteness" (2007). These insights can only be developed through interdisciplinary collaboration, yet the practices through which the legal, technical, and strategic functions of a firm come together have not been of interest to most organizational scholars.

Sharpening Our Toolbox. This approach to studying knowledge accumulation raises serious methodological challenges. How should we measure knowledge accumulation? Can we move beyond measures that capture the rate of accumulation to encompass the direction or diversity of accumulation? Current studies of the impact of a particular institution, rule, or norm on knowledge accumulation use simple measures. The most widespread outcome variable is a citation count—either to publications (as measured using the ISI-Thomson Web of Science database) or to patents using the U.S. Patent and Trademark Office data. For example, in their study of the impact of patent grant on the citation rate of scientific publications, Murray and Stern (2007) measure forward citations to publications as a proxy of knowledge accumulation. Furman and Stern (2006) used the same measure in their study of BRCs. Patent citations have also been applied to examine the potential impact of an institutional change such as postgrant patent opposition (Graham and Harhoff 2006).

This cumulative innovation research agenda would advance with richer measures of accumulation encompassing different types of knowledge from disparate contributors. For example, MacCormack et al. (2006) built design structure matrices to track changes in software architectures (e.g., the Linux operating system and the Mozilla browser) as different contributors participated in knowledge accumulation over time. Using modeling techniques, Baldwin and Clark (2006) found an increase in the modularity of software architecture enhanced participation rates and thus cumulative innovation.

Similarly, gene-by-gene annotations in the human genome database could be analyzed over time to acquire a window into knowledge accumulation in genetics research (Jensen and Murray 2005). Such analysis might reveal what factors are likely to attract new versus repeat contributors. In other fields, scholars can examine how communities creating new content (e.g., music, photos, art, reviews) are affected by changes in access, disclosure, or reward to see how member growth and rates and types of contributions change. However, three conditions are needed to foster these types of studies: (1) a common repository or record of multiparty contributions to a set of linked or interdependent innovations; (2) open access to such a resource; and (3) the ability to examine these data over time.

While existing and newly developed measures can proxy the rate of knowledge accumulation under different antecedent conditions, it is important to capture other outcomes. Using publication citations, it is possible to examine changes in the distribution of follow-on innovators along at least four dimensions: location (at the regional or national level), types of affiliation (academic or industry), disciplines (i.e., engineering versus physics), and quality (high- or low-impact journals). Some such distributive measures have been developed for patent citations (Henderson et al. 1998). Richer measures can also crafted from new sources of data. For example, gene sequence measures of knowledge accumulation might be parsed to examine the backgrounds of different contributors. Such measures of diversity are particularly valuable given that innovations drawing on diverse inputs are likely to have greater impact (Fleming and Sorenson 2003, Hargadon 2003).

Conclusion

We argue that the ability of future innovators to build cumulatively on an idea is not an inherent property of an innovation itself. Our synthesis of the economics and organizational theory literatures suggests rather that cumulative innovation is constrained or enabled by the degree to which the context provides three important conditions: access, disclosure, and rewards. Selected empirical and anecdotal examples show how these conditions are molded at the institution, field, community, and organization levels. Based on our framework and observations, this essay encourages organizational scholars to move beyond studies of knowledge flows to understand how changes in antecedent conditions affect the accumulation of knowledge. As our examples illustrate, such changes are not driven by the law alone. When innovators encounter (or erect) barriers to knowledge accumulation, the solutions they devise are often organizational ones. This suggests an expanding terrain for organizational scholars interested in exploring how multiple generations of innovators intent on cumulative innovation can use institutions, fields, organizations, and communities to pursue their goals.

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Endnotes

[1]The Federal Research Public Access Act of 2006 (S 2695 IS) was introduced in the Senate by Senators Cornyn (R-TX)

and Lieberman (I-CT) to "provide for federal agencies to develop public access policies relating to research conducted by employees of that agency or from funds administered by that agency."

[2]At the time of this writing, French lawmakers supported a draft bill ruling that closed and proprietary music platforms are anticompetitive and mandating access across providers. This ruling would affect providers of closed music platforms such as Apple's iTunes.

[3]*U.S. vs. Microsoft*. 2002. Civil Action No. 98-1232 (CKK), United States District Court (November 12) 2002. http://www.us.doj.gov/atr/cases/f200400/200457.htm.

[4]See http://www.ibm.com/ibm/licensing/patents/pledgedpatents.pdf for IBM's pledge of nonassertion (granting the free use of its patents) as well as the list of the 500 software patents.

[5]http://news.netcraft.com/archives/web_server_survey.html.

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