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Policy Challenges of Open, Cumulative, and User Innovation

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INTRODUCTION

The work of Alfred D. Chandler, Jr. (1918–2007), chronicles the development of the leading industrial firms such as General Motors and DuPont.[1] In Chandler's telling, such modern United States industrial firms emerged in the first half of the 20th century through an integrated value chain linking research and development ("R&D"), manufacturing, and distribution.[2]

In his 2003 book, *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Henry Chesbrough argued that the Chandlerian paradigm of vertical integration had become obsolete in both theory and practice.[3] Studying companies such as IBM and Proctor & Gamble, he described an emerging "open innovation paradigm," in which firms work beyond their boundaries to obtain and commercialize innovation, a paradigm that heavily has

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1. *See* ALFRED D. CHANDLER, JR., THE VISIBLE HAND: THE MANAGERIAL REVOLUTION IN AMERICAN BUSINESS (1977); ALFRED D. CHANDLER, JR., SCALE AND SCOPE: THE DYNAMICS OF INDUSTRIAL CAPITALISM (1990).

2. CHANDLER, THE VISIBLE HAND, *supra* note 1; CHANDLER, SCALE AND SCOPE, *supra* note 1.

3. *See* HENRY CHESBROUGH, OPEN INNOVATION: THE NEW IMPERATIVE FOR CREATING AND PROFITING FROM TECHNOLOGY (2003); *see also* OPEN INNOVATION: RESEARCHING A NEW PARADIGM (Henry Chesbrough et al. eds., 2006); Oliver Gassmann, Editorial, *Opening Up the Innovation Process: Towards an Agenda*, 36 R&D MGMT. 223, 223–26 (2006) (introducing a special issue on open innovation).

influenced recent research in innovation.[4] Chesbrough, however, is neither the first nor the only scholar to suggest that the actual (or best) practice of innovation goes beyond the boundaries of the firm.

Two other broad streams of innovation research explicitly span organizational boundaries. One is the user innovation paradigm developed by Eric von Hippel, which focuses on the role of informed users in improving and extending products.[5] The other stream in economics and sociology considers the cumulative innovation efforts across various, often competing, firms, exemplified by the work of Suzanne Scotchmer.[6]

Although these three critiques share an interorganizational perspective, they focus on different sources of innovation outside the firm.[7] In this Article, I contrast the implications of these three theories of interorganizational innovation[8] for the Chandlerian model of industrial innovation. I then analyze the potential impact of various public policies upon such interorganizational innovation and suggest opportunities for research in this area.

I. CONTRASTING MODELS OF INTERORGANIZATIONAL INNOVATION

There are three major perspectives on interorganizational innovation: user-contributed innovation, collective and cumulative innovation, and open innovation.

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4. *See generally* CHESBROUGH, *supra* note 3.

5. *See* ERIC VON HIPPEL, THE SOURCES OF INNOVATION 25–26 (1988).

6. SUZANNE SCOTCHMER, INNOVATION AND INCENTIVES (2004) (providing the first complete explanation of the theoretical and practical imperatives behind policies promoting cumulative innovation). Other key works include Nancy Gallini & Suzanne Scotchmer, *Intellectual Property: When Is It the Best Incentive System?*, *in* INNOVATION POLICY AND THE ECONOMY 51, 65–69 (Adam B. Jaffe et al. eds., 2002); Fiona Murray & Siobhán O'Mahony, *Exploring the Foundations of Cumulative Innovation: Implications for Organization Science*, 18 ORG. SCI. 1006 (2007).

7. *See* Table 1, *infra*.

8. When individual users are providing innovations to an organization, the modifier "extra-organizational" might be more accurate than "interorganizational." For simplicity's sake, the term "interorganizational innovation" is used herein to subsume all manifestations and extensions of the user, cumulative, and open innovation frameworks.

A. Von Hippel: User Innovation

In his original study, *The Sources of Innovation*, von Hippel argues that many firms have successfully found ideas for commercially important innovations outside the firm.[9] Although the book mentions suppliers as a possible source of innovation, von Hippel's ideas focus primarily on buyer innovation, particularly at the individual level.[10] For example, in his 2005 book *Democratizing Innovation*, von Hippel's stated goal is to document that "users of products and services—both firms and individual consumers—are increasingly able to innovate for themselves."[11]

The user innovation paradigm is most broadly applied in the study of open source software, which arose in the 1980s as an alternate means of producing an information good.[12] Open source software typically is developed by a loosely organized federation of individual users. The Apache open source web server is an example of one of the most successful and studied open source projects. Based on the university-developed NCSA server, Apache was developed by a group of webmasters beginning in 1995 to solve their own needs.[13] The Apache case illustrates that the user innovation paradigm is consistent with both the practice and the motivations of individual open source programmers, which have been captured by Raymond's oft-quoted aphorism that "[e]very good work of software starts by scratching a developer's personal itch."[14]

Research on user innovation in open source examines the benefits and origins of user-contributed innovations, as well as the various approaches to facilitating user innovation through technical design

9. VON HIPPEL, *supra* note 5.

10. *Id.*

11. ERIC VON HIPPEL, DEMOCRATIZING INNOVATION 1 (2005).

12. A discussion of the origins of open source software can be found in OPEN SOURCES: VOICES FROM THE OPEN SOURCE REVOLUTION (Chris DiBona et al. eds., 1999), and JOSEPH FELLER & BRIAN FITZGERALD, UNDERSTANDING OPEN SOURCE SOFTWARE DEVELOPMENT (2002). A taxonomy of the multiple dimensions of open source production is given by Joel West & Siobhán O'Mahony, *The Role of Participation Architecture in Growing Sponsored Open Source Communities*, 15 INDUSTRY & INNOVATION 145 (2008).

13. Brian Behlendorf, *Open Source as a Business Strategy*, *in* OPEN SOURCES: VOICES FROM A REVOLUTION 149 (Chris DiBona et al. eds., 1999).

14. ERIC S. RAYMOND, THE CATHEDRAL AND THE BAZAAR*:* MUSINGS ON LINUX AND OPEN SOURCE BY AN ACCIDENTAL REVOLUTIONARY 23 (rev. ed. 2001).

choices.[15] Other researchers have extended the study of user innovation beyond software to sporting goods[16] and music software.[17]

Nearly all of the user innovation literature focuses on the actions of autonomous individuals acting out of their own motivations. But von Hippel's original studies of user innovation involved business users modifying products for work-related use, such as engineers improving electronic instruments.[18] The theory rarely has been applied to corporate motivations for contributing innovations, which would be more consonant with the open innovation approach. Open innovation may be more appropriate for explaining the self-interested role of corporations in creating open source software; this is particularly true for firms that create such software not for their own use, but rather to support the sale of other goods and services.[19]

B. Scotchmer: Cumulative Innovation

A second stream of interorganizational innovation derives from the observation that technological progress is built upon a sequence of technical advances, both large and small.

Although the innovation literature, patent system, and fame and fortune often reward breakthrough innovation, most technologies are refined through a constant stream of incremental improvements. Even if a new technology starts as the product of one firm, it usually

15. *See generally* Karim R. Lakhani & Eric von Hippel, *How Open Source Software Works: "Free" User-to-User Assistance*, 32 RES. POL'Y 923 (2003); Georg von Krogh, Sebastian Spaeth & Karim R. Lakhani, *Community, Joining, and Specialization in Open Source Software Innovation: A Case Study*, 32 RES. POL'Y 1217 (2003). For a discussion of user innovation toolkits, see Nikolaus Franke & Eric von Hippel, *Satisfying Heterogeneous User Needs via Innovation Toolkits: The Case of Apache Security Software*, 32 RES. POL'Y 1199 (2003).

16. *See, e.g.*, Nikolaus Franke & Sonali Shah, *How Communities Support Innovative Activities: An Exploration of Assistance and Sharing Among End-Users*, 32 RES. POL'Y 157 (2003); Christoph Hienerth, *The Commercialization Of User Innovations: The Development of the Rodeo Kayak Industry*, 36 R&D MGMT. 273, 274 (2006).

17. *See, e.g.*, Lars B. Jeppesen & Lars Frederiksen, *Why Do Users Contribute to Firm-Hosted User Communities? The Case of Computer-Controlled Music*, 17 ORG. SCI. 45 (2006).

18. *See generally* VON HIPPEL, *supra* note 5, at 11–13.

19. For an explanation of how firms address open innovation challenges using open source software, see Joel West & Scott Gallagher, *Challenges of Open Innovation: The Paradox of Firm Investment in Open-Source Software*, 36 R&D MGMT. 319 (2006).

attracts a host of new and existing competitors who seek to improve upon the original breakthrough.

The cumulative innovation literature considers the role of this interdependence of producers and the consequential flows of information within an industry for developing and refining a new technology. Building upon the "collective invention" work of Robert Allen,[20] this stream is most recently associated with the work of Suzanne Scotchmer.[21]

This body of work considers two different manifestations of cumulative innovation. In the first, various parties successively refine a single technology until the improved technology is widely used by a range of producers.[22] Two well-documented examples of cooperation among competitors during the English industrial revolution are the blast furnace[23] and the Cornish mining pump.[24] This pattern continued into the 20th century with the development of lasers[25] and open source software.[26] Such shared leadership of technological progress—a diversified innovation base—means that progress does not depend on any one individual or firm. In many cases, this diversified base is essential to both the development and production of these innovations.

Cumulative innovation also can result from the combined innovation efforts of multiple users. A number of the aforementioned studies on user innovation center on the cumulative effects of a community of users, each building upon the other's efforts.[27] These combined efforts correspond to both user and cumulative innovation.

The other pattern of cumulative innovation occurs when firms build upon a common, ever-increasing pool of enabling science, even

20. *See generally* Robert C. Allen, *Collective Invention*, 4 J. ECON. BEHAV. & ORG. 1 (1983).

21. SCOTCHMER, *supra* note 6; Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J. ECON. PERSP. 29 (1991).

22. Allen, *supra* note 20, at 1–2.

23. *See generally* Allen, *supra* note 20.

24. *See generally* Alessandro Nuvolari, *Collective Invention During the British Industrial Revolution: The Case of the Cornish Pumping Engine*, 28 CAMBRIDGE J. ECON. 347 (2004).

25. *See* SCOTCHMER, *supra* note 6, at 127–29.

26. *See* Murray & O'Mahony, *supra* note 6, at 1013–15.

27. *See, e.g.*, Hienerth, *supra* note 16 (discussing cumulative user innovation in the rodeo kayak industry).

if their specific products are unique point products. The best-known example of this is biopharmaceutical drug discovery.[28]

In some cases, cumulative innovation is fueled by explicit cooperation between firms; in other cases, an industry's joint innovation is advanced through unintended spillovers and information flows among the firms in the industry. In the latter case, cumulative innovation happens to the degree to which it is permitted by intellectual property ("IP") policies: Firms use whatever information is available to develop their innovations. Thus, IP monopolies tend to slow the rate of innovation and progress.[29] At best, such innovation drag delays the pace of developing and diffusing an innovation.

At worst, this drag can create a negative-sum innovation standoff. An extreme example of such a standoff is given by the development of vacuum tubes in the early 20th century.[30] After the diode tube was invented and patented by Guglielmo Marconi, Lee De Forest improved the design by adding a third element to form a triode.[31] But because the triode infringed on Marconi's patent, U.S. courts ruled that neither De Forest nor Marconi could legally sell a triode without a license from the other, which each side refused to grant.[32] Development of the U.S. broadcasting industry was blocked until the stalemate was resolved.[33]

C. Chesbrough: Open Innovation

Like cumulative and user innovation, open innovation builds upon the assumption of dispersed capabilities for identifying and implementing innovations.[34] Although user innovation and

28. The cumulative nature of drug discovery is discussed by SCOTCHMER, *supra* note 6, and Murray & O'Mahony, *supra* note 6, at 1011–13.

29. *See* Scotchmer, *supra* note 21, at 32–35.

30. ADAM B. JAFFE & JOSH LERNER, INNOVATION AND ITS DISCONTENTS: HOW OUR BROKEN PATENT SYSTEM IS ENDANGERING INNOVATION AND PROGRESS, AND WHAT TO DO ABOUT IT 50–51 (2004).

31. *Id*. at 51.

32. *Id*.

33. Carole E. Scott, *The Radio Inventor/Entrepreneurs*, BUS. QUEST, 2001, http://www.westga.edu/~bquest/2001/radio.htm.

34. Key definitions of the domain of open innovation are provided by CHESBROUGH, *supra* note 3, at xvii–xxxi, and Henry Chesbrough, *Open Innovation: A New Paradigm for*

cumulative innovation focus on consumer welfare, the open innovation paradigm emphasizes the opportunities for profit and competitive advantage by individual firms. These differing assumptions and emphases cause the contrasting approaches to examine the same phenomenon and reach different conclusions.

Chesbrough defines open innovation as

> [T]he use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology.[35]

In other words, innovation should be treated like any other input to the industrial firm—something that can be bought and sold on the open market, not just produced and used within the boundaries of the firm. Applying Oliver Williamson's transaction cost economics framework,[36] under open innovation, firms use markets to supplement internal hierarchies as mechanisms for both sourcing and commercializing innovations. Using markets to source and commercialize innovations offers the benefits of competition and diversification of risk over the fully vertically integrated approach.

In many cases, however, the relationships are not one-time atomic transactions but a series of ongoing relationships corresponding to Powell's network form of organization.[37] In fact, the production of many complex products inherently depends on the cooperation of firms within a value network.[38] Such value networks are quite

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Understanding Industrial Innovation, *in* OPEN INNOVATION: RESEARCHING A NEW PARADIGM, *supra* note 3, at 1.

35. Chesbrough, *supra* note 34, at 1. Chesbrough's usage of "open innovation" is today the most common, but not the only usage of the term. In some cases, the reference to "open" innovation indicates a generic form of openness. *See, e.g.*, Lee Fleming & David M. Waguespack, *Brokerage, Boundary Spanning, and Leadership in Open Innovation Communities*, 18 ORG. SCI. 165 (2007).

36. This framework is set out in OLIVER E. WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM: FIRMS, MARKETS, RELATIONAL CONTRACTING 15–42 (1985).

37. *See* Walter W. Powell, *Neither Market Nor Hierarchy: Network Forms of Organization*, 12 RES. ORG. BEHAV. 295 (1990).

38. For a synthesis of prior research on value networks and its applicability to open innovation, see Wim Vanhaverbeke, *The Inter-organizational Context of Open Innovation*, *in*

common in systems-based industries. Where once vertical integration was the norm—as represented by IBM in computers or Motorola in cellular telephones—it has been supplanted by horizontal specialization, fueled by strong economies of scale for key components.[39] The efficient subdivision of labor among key members of the value network is enabled by technical modularity.[40] Innovation in such systems, however, often requires a firm or group of firms to lead and shape the innovation occurring within a value network.[41]

II. POLICIES TO ENCOURAGE INTERORGANIZATIONAL INNOVATION

Even though the empirical record is still developing, researchers have provided evidence that interorganizational innovation can be faster, more efficient, and more diversified than the alternative approaches for developing and commercializing innovations. Policy-makers thus should be concerned with the effect various public policies will have on the prevalence and effectiveness of interorganizational innovation.

Most of the factors affecting buy-versus-make innovation decisions remain under the purview of individual firms. A number of policy decisions, however, can affect both the supply and cost of

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OPEN INNOVATION: RESEARCHING A NEW PARADIGM, *supra* note 3, at 210–15. The definition of "value network" put forth by Vanhaverbeke (and others in the same volume) seems exactly equivalent to the business "ecosystem" discussed in MARCO IANSITI & ROY LEVIEN, THE KEYSTONE ADVANTAGE: WHAT THE NEW DYNAMICS OF BUSINESS ECOSYSTEMS MEAN FOR STRATEGY, INNOVATION, AND SUSTAINABILITY 8–10 (2004), and, in fact, they cite this ecosystem research. *Id*. In contrast to the familiar Porter "value chain," *see* MICHAEL E. PORTER, COMPETITIVE ADVANTAGE: CREATING AND SUSTAINING SUPERIOR PERFORMANCE 33–39 (1985), the open innovation value network includes other paths for value creation beyond the value chain, notably companies selling goods and services that are complementary to the value created by the focal firm.

39. *See* Joel West, *Does Appropriability Enable or Retard Open Innovation?*, *in* OPEN INNOVATION: RESEARCHING A NEW PARADIGM, *supra* note 3, at 109, 112–14; ANDREW S. GROVE, ONLY THE PARANOID SURVIVE: HOW TO EXPLOIT THE CRISIS POINTS THAT CHALLENGE EVERY COMPANY AND CAREER 48–52 (1996); THE BUSINESS OF SYSTEMS INTEGRATION, 206–11 (Andrea Prencipe et al. eds., 2003).

40. CARLISS Y. BALDWIN & KIM B. CLARK, DESIGN RULES, VOL. 1: THE POWER OF MODULARITY 364 (2000); Richard N. Langlois, *Modularity in Technology and Organization*, 49 J. ECON. BEHAV. & ORG. 19, 23 (2003).

41. *See* Markku Maula, Thomas Keil & Jukka-Pekka Salmenkaita, *Open Innovation in Systemic Innovation Contexts*, *in* OPEN INNOVATION: RESEARCHING A NEW PARADIGM, *supra* note 3, at 241.

external innovations—and thus the likelihood that firms will consider and adopt such external innovations rather than developing their own, or not innovating at all.

In this Article, I examine five policy levers: (1) intellectual property, (2) public funding of R&D, (3) public funding of infrastructure, (4) regulation of competition, and (5) taxation. I use these levers to show how both business strategies and policy choices are interpreted within the tenets of the three types of interorganizational innovation.

A. Strength of the IP Regime

The core research question for economic studies of cumulative innovation has been determining the appropriate type and strength of innovation incentives. Researchers seek to balance the need for adequate incentives to encourage investment in innovation with the need to reduce drag on the cumulative innovation that occurs between firms across a given industry or segment. Although Scotchmer discusses and evaluates alternative innovation incentives such as invention prizes,[42] most of the research and policy discussion has focused on the appropriate strength of the IP protection mechanisms.[43]

Below I consider the effects that strengthening (or weakening) patent and copyright protection might have on interorganizational innovation. The three theories of interorganizational innovation focus on different consequences of changing the strength of a national IP regime.[44]

42. SCOTCHMER, *supra* note 6, at 41–46.

43. *See, e.g.*, JAFFE & LERNER, *supra* note 30; Howard F. Chang, *Patent Scope, Antitrust Policy, and Cumulative Innovation*, 26 RAND J. ECON. 34 (1995); Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998); Adam B. Jaffe, *The U.S. Patent System in Transition: Policy Innovation and the Innovation Process*, 29 RES. POL'Y 531 (2000).

44. *See* Table 2, *infra*.

1. Patent Regimes

The United States and other developed economies have seen a wide range of proposals in the past decade for patent policy reform, many of which are intended to undo prior reforms that strengthened the enforceability of patents as an incentive for small inventors.[45] Some of these reforms would be quite modest, such as reducing protection for trivial ideas by making it easier to overturn weak patents.[46] Other proposed changes are more dramatic.

A fundamental concern of cumulative innovation is that an excessively broad grant of IP rights will shut down cumulative innovation because a second innovator building on the efforts of the first will lack the incentive to develop the necessary extensions and improvements.[47]

Even if no individual firm has a monopoly on the IP, the collective IP rights positions of a group of firms can serve as a barrier to new entrants and thus to new innovation. In the case of European GSM mobile phone standards, the patent positions of Nokia, Ericsson, Siemens, Alcatel, and Motorola meant that no outside firm could produce a mobile phone without licensing the patents of all firms.[48] As was intended by the incumbent producers, for many years this patent barrier excluded from the European market the Japanese manufacturers that were leading the world in miniaturization.[49] In

45. A complete review of the recent criticisms and proposals for reform is beyond the scope of this Article. For recent economic analyses of the problems in the current U.S. patent system, including those caused by patent "reforms" of the 1980s and 1990s, and proposals for counter-reform, see JAFFE & LERNER, *supra* note 30, at 151–69; Nancy Gallini, *The Economics of Patents: Lessons from Recent U.S. Patent Reform*, 16 J. ECON. PERSP. 131 (2002); Carl Shapiro, *Patent Reform: Aligning Reward and Contribution* (National Bureau of Econ. Research, Working Paper No. W13141, 2007), *available at* http://ssrn.com/abstract=989952.

46. Examples of such reforms can be seen in JAFFE & LERNER, *supra* note 30, at 170–207; Stuart J.H. Graham & Dietmar Harhoff, *Can Post-Grant Reviews Improve Patent System Design? A Twin Study of US and European Patents* 4 (Centre for Econ. Pol'y Research, Discussion Paper No. 5680, 2006), *available at* http://ssrn.com/abstract=921826.

47. Scotchmer, *supra* note 21, at 32.

48. For a discussion of the role of patents in the GSM standard and as a barrier to entry, see RUDI BEKKERS, MOBILE TELECOMMUNICATIONS STANDARDS: GSM, UMTS, TETRA, AND ERMES 321–27 (2001).

49. The rapid rate of improvements in size and weight by Japanese cell phone manufacturers is documented in Jeffrey L. Funk, *Standards, Dominant Designs and*

fact, the barriers posed by GSM patents were not widely known until they were used against Sendo, a British startup founded in 1999: in March 2005, Ericsson sued Sendo for patent infringement; Sendo brought a counter-complaint to the European Commission, which was not resolved before the company went out of business three months later.[50] Despite this protection, of the four European incumbents, only Nokia remained in the handset business: Siemens and Alcatel sold their money-losing handset divisions to smaller Asian rivals, and Ericsson combined its operations in a joint venture with Tokyo-based Sony.[51]

Thus, decreasing the scope or duration of patent claims would recognize and encourage the practice of cumulative innovation within an industry. Such changes, however, could decrease the attractiveness of business models based on developing and licensing IP to external customers, a key strategy available within open innovation.[52] Because such licensing models are controversial, some stakeholders would view the end of open innovation as a good thing.

2. Copyright

Concerns about strong IP regimes deterring interorganizational innovation are not limited to patent policy. In some ways, copyright is the area of greatest policy experimentation, as right-holders experiment by unilaterally granting additional rights within existing national policy. These rights are designed to encourage experimentation in user or cumulative innovation.

The initial experiments came with the creation of licenses for free and open source software.[53] The free software movement and the

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Preferential Acquisition of Complementary Assets Through Slight Information Advantages, 32 RES. POL'Y 1325, 1331–34 (2003).

50. For a discussion of Ericsson's patent infringement lawsuit against Sendo and Sendo's complaint to the European Commission, see Sean Jackson, *When Sendo Met Ericsson*, MOBILE COMM. INT'L, Apr. 1, 2005.

51. For a post-mortem on Sendo after its sale to Motorola, see *id.*; Mike Dano, *Motorola Buys Sendo's R&D, Patents*, RCR WIRELESS NEWS, July 4, 2005. For a summary of the GSM patent situation, as well as a chronology of the exit by the three European cell phone makers, see West, *supra* note 39, at 125–28.

52. The role of patent licensing as part of an open innovation strategy was first outlined by CHESBROUGH, *supra* note 3, at 155–76.

53. For a complete treatment of the use of copyright and contract law in open source

open source software movement share similar technical approaches but different underlying philosophies.[54] Free software is explicitly predicated on a user innovation model.[55] Open source software is designed to facilitate what is now called open innovation—creating shared IP that can be used as a source of external innovations by for-profit entities.[56] Both approaches enable cumulative innovation, for the copyright licenses explicitly encourage sharing and thus further decentralize the innovation process. Not all open source software strategies, however, are open innovation or vice versa.[57]

An entire class of literary or artistic expression, typically covered by copyright, is based upon recombining, elaborating upon, or satirizing prior art;[58] a common example is the creation of new songs that incorporate digital samples of one or more prior songs.[59] Although such recombinations have been blocked by some rights holders, other rights holders have sought to encourage recombinations. The "creative commons" licenses are intended to facilitate this form of interorganizational innovation; they build upon the concepts and principles developed for free and open source licenses.[60]

Like stronger patent regimes, stronger copyright regimes can discourage the practice of cumulative innovation or delay it by introducing a high degree of uncertainty to the process. On the other

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licenses, see generally LAWRENCE ROSEN, OPEN SOURCE LICENSING: SOFTWARE FREEDOM AND INTELLECTUAL PROPERTY LAW (2004).

54. *See* Jason Dedrick & Joel West, *Movement Ideology vs. User Pragmatism in the Organizational Adoption of Open Source Software*, *in* COMPUTERIZATION MOVEMENTS AND TECHNOLOGY DIFFUSION: FROM MAINFRAMES TO UBIQUITOUS COMPUTING 427 (Kenneth L. Kraemer & Margaret Elliott eds., 2008).

55. *See* Eric von Hippel, *Innovation by User Communities: Learning from Open-Source Software*, 42 SLOAN MGMT. REV. 82 (2001).

56. Behlendorf, *supra* note 13; Joel West & Scott Gallagher, *Patterns of Open Innovation in Open Source Software*, *in* OPEN INNOVATION: RESEARCHING A NEW PARADIGM, *supra* note 3, at 82, 91.

57. For an explanation of the orthogonal typologies of open source and open innovation, see West & Gallagher, *supra* note 56, at 101–02.

58. LAWRENCE LESSIG, FREE CULTURE: HOW BIG MEDIA USES TECHNOLOGY AND THE LAW TO LOCK DOWN CULTURE AND CONTROL CREATIVITY 24 (2004), *available at* http://www.free-culture.cc.

59. For a discussion of digital mixing of film, music, and other media, see *id*. at 105–06.

60. A summary of the goals of Creative Commons can be found in Lawrence Lessig, *The Creative Commons*, 65 MONT. L. REV. 1 (2004).

hand, weaker copyright regimes can shift incentives away from unique contributions toward more derivative ones. As with other weaker IP regimes, lack of effective copyright protection particularly will reduce innovation by smaller firms that lack the ability to directly commercialize their innovation.[61]

The creation of new copyright licenses (open source, free software, and creative commons) shows that the existing copyright law can be used to facilitate, rather than deter, cumulative innovation, but court tests of these mechanisms remain scarce.[62]

B. Funding and Managing Public R&D

Another heavily debated and studied area of innovation policy during the past twenty years concerns government-funded innovations. The debate focuses on the level of funding and the allocation of rights but also considers policies related to developing, managing, and diffusing such innovations.

The role of government R&D funding in fueling interorganizational innovation comes in two major ways: through spillovers of government-funded research, and through direct commercialization of innovations developed with government funding.

1. Research Spillovers

Innovations from government research labs, government-funded university projects, and other public sources (including university-funded research) were traditionally allowed to spillover freely to the private sector in a model Chesbrough termed an "innovation benefactor."[63] Such funding for innovation is a public good provided

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61. *See* David J. Teece, *Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy*, 15 RES. POL'Y 285, 297 (1986).

62. The scarcity of court tests is remarked most recently by Mark Driver. Posting of Mark Driver to Gartner, http://blogs.gartner.com/mark_driver/2009/01/27/open-source-lawsuit-makes- it-to-court/ (Jan. 27, 2009) (posting entitled "Open Source Lawsuit Makes It to Court").

63. Henry W. Chesbrough, *The Era of Open Innovation*, 44 SLOAN MGMT. REV. 35, 38–39 (2003). For many, an "open" model of innovation (which is not necessarily "open innovation") refers to this "innovation benefactor" model of non-monetized information flows

to promote societal welfare.[64] This approach should increase cumulative innovation, for the public spillovers to a wide range of commercial actors diversify the supply of potential innovators who can build on that public science.

In the United States, the government's role as the largest innovation benefactor was cemented during World War II, when the Office of Scientific Research and Development funneled government money to fund R&D in universities and private industry.[65] Under the direction of OSRD chairman Vannevar Bush, postwar research funding was divided into two categories: basic and applied.[66] Broad categories of basic research were funded by the National Science Foundation, which was created in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense."[67] Meanwhile, the National Institutes of Health were created in 1948 to consolidate various public health research activities dating back to 1798.[68]

For the first three decades of the postwar electronics industry, however, the largest source of research spillovers came from military funding of university research.[69] This funding led to technological innovation and major business opportunities in semiconductors, digital computers, software, data communications, and

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but explicitly excludes the emphasis of Chesbrough's work (especially CHESBROUGH, *supra* note 3) on buying and selling innovations.

64. *See* Joel West, Wim Vanhaverbeke & Henry Chesbrough, *Open Innovation: A Research Agenda, in* OPEN INNOVATION: RESEARCHING A NEW PARADIGM, *supra* note 3, at 285, 300.

65. The federal government accounted for the majority of U.S. R&D spending from the 1950s through the end of the 1970s. *See* Adam B. Jaffe, *Trends and Patterns in Research and Development Expenditures in the United States*, 93 PROC. NAT'L ACADEMIES SCI. U.S. AM. 12658 (1996).

66. VANNEVAR BUSH, SCIENCE THE ENDLESS FRONTIER (1945) (report to the President by the Director of the Office of Scientific Research and Development).

67. NAT'L SCI. FOUND., *Historical Background of the National Science Foundation*, FY 1952 BUDGET REP., app. I (1952), *available at* http://www.nsf.gov/pubs/1952/; *see also* NAT'L SCI. FOUND., *Legislative History of the NSF Act of 1950,* FY 1952 BUDGET REP., app. II (1952), *available at* http://www.nsf.gov/pubs/1952/.

68. NAT'L INST. OF HEALTH, THE NIH ALAMANAC-HISTORICAL DATA (2008), *available at* http://www.nih.gov/about/almanac/historical/chronology_of_events.htm.

69. A comprehensive summary of the role of the U.S. government in funding computer research from ENIAC into the 1980s is presented by KENNETH FLAMM, CREATING THE COMPUTER: GOVERNMENT, INDUSTRY, AND HIGH TECHNOLOGY 29–51 (1988).

telecommunications.[70] The government funded major research projects at elite universities, both directly and through the Joint Services Electronics Program.[71] Spillovers of government funding to universities helped to create key aspects of the U.S. computer industry, including:

- *Univac I.* After using Army funding to build the ENIAC I at the University of Pennsylvania, Professor John Mauchly and student J. Presper Eckert left the university and went on to launch what became the Eckert-Mauchly Computer Corporation; in 1950, this corporation built the Univac I, the first digital computer ever sold for civilian use.[72]

- *Core Memory.* Beginning in 1944, the Office of Naval Research funded Project Whirlwind computer research at the Massachusetts Institute of Technology ("MIT").[73] Among other things, the project invented the magnetic core memory that was used commercially in IBM's 704 and 705 computers and nearly all computers for the next twenty-five years.[74] In one of the rare exceptions to free university spillovers, MIT earned $22 million in patent royalties on core memory (mostly from IBM).[75]

- *IBM's mainframe dominance.* MIT's successor to Whirlwind was incorporated into Project SAGE, a massive air defense radar system developed by MIT, IBM, and the RAND Corporation from 1952–1958.[76] During SAGE's peak in the 1950s, 25% of IBM employees worked on the

70. *See id*.

71. Leo Young, *Electronics and Computing*, 502 ANNALS AM. ACAD. POL. & SOC. SCI. 82, 86–88 (1989).

72. *See* FLAMM, *supra* note 69.

73. KARL L. WILDES & NILO A. LINDGREN, A CENTURY OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE AT MIT, 1882–1982, at 289 (1985).

74. Project Whirlwind, core memory, and the SAGE air defense system are discussed in WILDES & LINDGREN, *id*. at 296–300, and in Chapter 4 of NAT'L RESEARCH COUNCIL, FUNDING A REVOLUTION: GOVERNMENT SUPPORT FOR COMPUTING RESEARCH 92–95 (1999).

75. ROBERT BUDERI, THE INVENTION THAT CHANGED THE WORLD: HOW A SMALL GROUP OF RADAR PIONEERS WON THE SECOND WORLD WAR AND LAUNCHED A TECHNOLOGICAL REVOLUTION 403 (1996).

76. WILDES & LINDGREN, *supra* note 73, at 299–300.

project, and it accounted for half of IBM's computer revenues.[77] IBM's president later credited the project with allowing IBM to surpass Univac once and for all.[78]

- *Airline Reservation Systems.* IBM adapted the SAGE hardware to build SABRE, the American Airlines reservation system dubbed "Kid's SAGE," which was the largest ever commercial systems development project at the time of its completion in 1964.[79]

- *Digital Equipment Corporation.* Kenneth Olsen did his 1952 MIT master's thesis on core memory and then worked at MIT Lincoln Lab monitoring IBM's manufacturing of the SAGE computers.[80] In 1957, he left Lincoln Lab, started DEC, and began work on the PDP-1, the first of nine minicomputer models that the firm would ship during the next two decades.[81]

- *Internet.* Defense Department funding of the ARPANET from 1968 to 1990 produced a military communications network that was robust against military attack; this network also provided the infrastructure and standards later used to build the commercial Internet, which in turn fueled an explosive wave of innovation during the 1990s.[82]

- *Open Source Operating Systems.* As a side effect of government funding to develop these networking protocols, the University of California–Berkeley developed the BSD

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77. Project SAGE is discussed by BUDERI, *supra* note 75, at 380–406, and by WILDES & LINDGREN, *supra* note 73, at 299–300. The impact of Project SAGE upon IBM's business is recounted in MARTIN CAMPBELL-KELLY, FROM AIRLINE RESERVATIONS TO SONIC THE HEDGEHOG: A HISTORY OF THE SOFTWARE INDUSTRY 38 (2003), as well as in THOMAS J. WATSON, JR. & PETER PETRE, FATHER, SON & CO.: MY LIFE AT IBM AND BEYOND 229–34 (1991).

78. Tom Watson, Jr., later wrote: "SAGE . . . gave IBM the giant boost I was after. . . . [I]t enabled us to build highly automated factories ahead of anybody else, and to train thousands of new workers in electronics." WATSON & PETRE, *supra* note 77, at 233.

79. CAMPBELL-KELLY, *supra* note 77, at 41–45.

80. WILDES & LINDGREN, *supra* note 73, at 298.

81. *Id.* at 232.

82. David C. Mowery & Tim Simcoe, *Is the Internet a US Invention? An Economic and Technological History of Computer Networking*, 31 RES. POL'Y 1369, 1372–75 (2002).

> variant of Unix, which helped diffuse the TCP/IP protocols and provided key operating system components later used by Sun Microsystems, Linux, and Apple's OS X.[83]

The impact of defense spillovers on the electronics industry was not limited to computing technologies. The military funded key university research in semiconductors and integrated circuits that later became commonplace in industry, including new materials, solid-state circuits, and computer-aided circuit design.[84] Meanwhile, digital communications were developed through a combination of Department of Defense ("DoD")-funded basic research and NASA-funded applications for deep space communications, which together enabled the creation of digital cellular phones.[85]

During the heyday of the 1960s, the bulk of federally funded research was tied to building complex systems for military uses and the space program, but the relative importance of such systems declined during the 1970s to 1990s.[86] Although government R&D funding supported the U.S. information technology sector during the 1960s and 1970s, the relative importance of federal R&D funding began a steep decline starting in 1988.[87]

2. Direct Commercialization

If the Internet epitomized the free spillover of university research to aid private innovation, the Bayh-Dole Act of 1980[88] represented the exact opposite philosophy. It assumed that the most effective path

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83. The role of the DoD-funded BSD Unix in the evolution of Unix and Linux is discussed in Joel West & Jason Dedrick, *Open Source Standardization: The Rise of Linux in the Network Era*, 14 KNOWLEDGE, TECH., & POL'Y 88, 93–94 (2001). A continuation of that discussion—linking it forward to Apple's OS X operating system—can be found in Joel West, *How Open Is Open Enough? Melding Proprietary and Open Source Platform Strategies*, 32 RES. POL'Y 1259, 1270–72 (2003).

84. Young, *supra* note 71, at 89.

85. Joel West, *Commercializing Open Science: Deep Space Communications as the Lead Market for Shannon Theory, 1960–1973*, 45 J. MGMT. STUD. 1506, 1522 (2008).

86. *See* Adam B. Jaffe, *Trends and Patterns in Research and Development Expenditures in the United States*, 93 PROC. NAT'L. ACAD. SCI. 12658 (1996).

87. *See* Kira R. Fabrizio & David C. Mowery, *Defense-Related R&D and the Growth of the Postwar Information Technology Industrial Complex in the United States*, 12 REVUE D'ECONOMIE INDUSTRIELLE 27, 28 (2005).

88. 35 U.S.C. §§ 200–211 (2000).

for commercializing university inventions was not through free spillovers from universities to industries, but rather through creating economic incentive for universities to commercialize their inventions.[89] Thus, the Act encouraged universities to patent innovations developed using federal money and then to license those innovations to private firms.[90] In open innovation terms, universities are thus transformed from innovation benefactors to innovation merchants.[91]

As with open innovation, direct commercialization assumes that strong incentives are needed to develop and commercialize innovations—specifically, that universities will not aid technology transfer and commercialization absent limitations on drag created by patenting public science. One study concluded that universities' attempts to capitalize on their innovations can potentially provide returns to the university, but that these attempts also create innovation drag and slow the process of cumulative innovation.[92] Others have argued that the overall empirical record is mixed and can be interpreted to either support or refute the predictions that innovation drag will slow the process of interorganizational innovation.[93]

C. Competition Policy

Although interorganizational innovation normally will promote a diversity of innovation sources and thus be pro-competitive, under certain conditions the associated industry structure might run afoul of antitrust or other national competition policies. In this section, I highlight three cases: a component-based open innovation model,

89. *Id.*

90. The rate of increased patenting by U.S. universities predates the Bayh-Dole Act, and thus the Act is both a reflection and a cause of a shift in the availability of free innovation spillovers. *See* David C. Mowery & Bhaven N. Sampat, *University Patents and Patent Policy Debates in the USA, 1925–1980*, 10 INDUS. & CORP. CHANGE 781, 782–83 (2001).

91. *See* Chesbrough, *supra* note 63, at 41; West et al., *supra* note 64, at 291.

92. Kira Fabrizio, *The Use of University Research in Firm Innovation*, *in* OPEN INNOVATION: RESEARCHING A NEW PARADIGM, *supra* note 3, at 134, 157.

93. Among the most vociferously agnostic are Charles R. McManis & Sucheol Noh, *The Impact of the Bayh-Dole Act on Genetic Research and Development: Evaluating the Arguments and Empirical Evidence to Date* (Wash. Univ. Sch. of Law, Working Paper, 2007), *available at* http://law.wustl.edu/crie/index.asp?ID=5906.

open standards, and explicit attempts to create cumulative innovation through R&D consortia or other efforts at R&D pooling.

1. Horizontal Component Monopolies

As noted by Grove, an alternative to the vertical integration in the information and communications technology ("ICT") industry (as with mainframe computers) is a component-integration model represented by microprocessor and operating system vendors supplying to personal computer makers.[94] Through increased volumes and market share, and by supplying to a wide range of competing vendors, successful component producers enjoy a range of supply- and demand-side economies of scale that tend to create quasi-monopolies in a given product category or segment.[95]

No matter how lawfully obtained, such successful quasi-monopolies are subject to antitrust scrutiny—particularly in Europe, where (unlike in the United States) competition policy considers the impact of market power on competitors, not just on consumers.[96] The small number of high profile cases against dominant component suppliers such as Microsoft, Intel, and Qualcomm makes it hard to generalize as to the broader impact of competition policy on future component/integration business models. Existing competition policy clearly seeks to limit the business strategies of component suppliers that achieve a dominant position in their segment. Both case law and regulatory policy, however, remain unsettled, in part because the economic effects of curtailing, restricting, or banning horizontal monopolies remain contested.[97]

Meanwhile, in response to antitrust criticisms, these component suppliers have sought to enlist allies from among their customers, particularly medium-sized and smaller buyers. These are the

94. GROVE, *supra* note 39, at 41–42.

95. *Id.* at 52.

96. One comparison of recent U.S. and E.U. competition policy is given by John P. Jennings, *Comparing the US and EU Microsoft Antitrust Prosecutions: How Level is the Playing Field*?, 2 ERASMUS L. & ECON. REV. 71 (2006).

97. As but one example, two prominent industrial economists presented contradictory assessments of the 1998–1999 *United States v. Microsoft* trial. *See* Franklin M. Fisher & Daniel L. Rubinfeld, United States v. Microsoft*: An Economic Analysis*, *in* DID MICROSOFT HARM CONSUMERS? TWO OPPOSING VIEWS 1 (David S. Evans et al. eds., 2000).

customers who most benefit from the availability of components and thus open innovation, for they would otherwise lack the scale and innovation capabilities to compete with large vertically integrated incumbents. The archetypal example is Dell Computer, formed by Michael Dell in 1983 in his college dormitory: The availability of off-the-shelf components allowed Dell to ship personal computers in competition with IBM.[98] By combining external sources of innovation with a ruthless focus on manufacturing efficiencies, within a decade, Dell left the vertically integrated IBM unable to compete on cost; IBM's losses eventually drove it out of the "IBM PC" computer business in 2004.[99]

2. Open Standards

Although there are many definitions of "open" standards, the fundamental issue is whether a standard facilitates entry and thus competition between rival suppliers.[100] Open entry facilitates the cumulative innovation of a broad innovation base, producing related (if not directly competing) products in a given industry segment or category.[101]

In setting competition policy for standardization efforts, regulators face conflicting imperatives based on the interests of various stakeholders.[102] For example, if the government approves a sharing of

98. Dell later wrote: "My Dad started. . . . 'Get your priorities straight. What do you want to do with your life?' 'I want to compete with IBM!' I said." MICHAEL DELL, DIRECT FROM DELL 10 (1999).

99. In 1992, one analyst estimated that matching Dell's prices would have brought IBM annual losses exceeding $1 billion. Andrew Kupfer, *Who's Winning the PC Price Wars?* FORTUNE, Sept. 21, 1992. In December 2004, IBM decided to sell its PC division to China's Lenovo after experiencing PC division losses of $965 million during the previous three and a half years. Nick Baker, *IBM's PC Business Unprofitable Since at Least 2001*, DOW JONES NEWSWIRES, Dec. 31, 2004.

100. For the economic implications of open standards, see Joel West, *The Economic Realities of Open Standards: Black, White and Many Shades of Gray*, *in* STANDARDS AND PUBLIC POLICY 87–122 (Shane Greenstein & Victor Stango eds., 2006). A proposal to operationalize definitions of open standards can be found in Ken Krechmer, *Open Standards Requirements*, 4 INT'L J. IT STANDARDS & STANDARDIZATION RES. 43 (2006).

101. West, *supra* note 100, at 88.

102. *Id*. at 96–98.

patent rights (e.g., by patent pool or cross-licensing)[103]—thus creating a patent cartel—it could facilitate cooperation among existing vendors at the expense of potential new entrants, or it could leverage this collusion to transfer rents from buyers to this cartel of producers.[104]

Irrespective of their regulatory role, government buyers (like other buyers) also can adopt policies favoring the production of goods based on open standards to encourage their provision, as happened in the open systems movement of the 1980s and 1990s.[105]

3. R&D Consortia

Another potential source of external innovations for firms is through cooperative R&D among suppliers, customers, and competitors. In this model, the R&D typically is funded by a consortium, and the consortium members share in its returns. Such prior agreements on research cooperation protect later inventors from hold-up by earlier ones, thus enabling the process of cumulative innovation.[106]

Any cooperation among competitors, however, is fraught with antitrust implications, thus generating many billable hours (and an occasional cancelled consortium) for attorneys seeking to navigate potential minefields. In the United States, R&D consortia were explicitly authorized by the National Cooperative Research Act of 1984 ("NCRA"), which reversed a policy decision of the 1890 Sherman Antitrust Act that banned such cooperation between direct competitors.[107] Although NCRA-compliant consortia often include just two direct competitors (a form of cumulative innovation), the cooperation may span an open innovation value network of

103. For a discussion of patent pools, see Carl Shapiro, *Antitrust Limits to Patent Settlements*, 34 RAND J. ECON. 391 (2003).

104. *Id*.

105. *See* Jim Isaak, *The Role of Individuals and Social Capital in POSIX Standardization*, 4 INT'L J. IT STANDARDS & STANDARDIZATION RES. 1, 1–23 (2006)

106. Scotchmer, *supra* note 21, at 32.

107. William M. Evan & Paul Olk, *R&D Consortia: A New U.S. Organizational Form*, 31 SLOAN MGMT. REV. 37, 37–45 (1990) (noting that although collaborative innovation in the United States required an act of Congress to eliminate antitrust concerns, such collaborative innovation was not considered illegal in Western Europe or Japan).

competitors, suppliers, and customers. Such was the case with the Plastics Recycling Foundation, which included makers of plastics and plastic-based packaging, as well as major buyers of such packaging.[108] Presumably, the direct involvement of industrial buyers would vitiate concerns that collaborative R&D is anti-competitive and harmful to the interests of buyers.

Antitrust issues presumably would be less in consortia where innovation benefits spill over to participants and non-participants alike, as with open source software consortia.[109] The applicability of this form for shared R&D, however, has yet to be expanded beyond software production.

D. Promoting Public Infrastructure

The Internet is perhaps the most successful publicly funded innovation infrastructure of the past century, and it provides an example of the role that government can play in the provision of common or non-rivalrous goods, particularly in cases where it would be impractical or inefficient for a private party to capture tolls for use of the infrastructure.[110] The success of the Internet suggests that public funding for innovative infrastructure can under some circumstances facilitate processes of interorganizational innovation by encouraging the widest possible range of innovation contributions. There are at least three mechanisms by which that innovation is facilitated.

First, as with other publicly funded research, public spillovers and lack of appropriability can fuel a virtuous cycle of adoption and enhancements. For the Internet, these spillovers encouraged entry by innovative users, suppliers, complementers, and rivals of existing firms. Such entry was further facilitated by the procurement policies of the U.S. government, which favored entry into data networking by

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108. *Id*.

109. West & Gallagher, *supra* note 19, at 322–24.

110. Discussions of the role of government in providing shared infrastructure can be found in Brett M. Frischmann, *Infrastructure Commons in Economic Perspective*, 12 FIRST MONDAY 6 (2007), and Steven J. Jackson, Paul N. Edwards, Geoffrey C. Bowker & Cory P. Knobel, *Understanding Infrastructure: History, Heuristics, and Cyberinfrastructure Policy*, 12 FIRST MONDAY 6 (2007).

small firms and did not allow the technological designs of any firm to dominate the architecture.[111]

Additionally, the process of standardizing infrastructure interfaces generally follows the best practices for multilateral standards setting organizations ("SSOs").[112] As such, it benefits from well-developed policies of these SSOs, which generally have been designed to facilitate a cumulative innovation process within an industry segment across a wide range of industry participants. The most successful example of information infrastructure, the Internet, created new forms of standardization, notably the Internet Engineering Task Force, which used new processes that were in many ways more open than earlier SSOs.[113]

Finally, such a process of interorganizational standardization creates alternatives to vertical integration and thus opportunities for open innovation. Well-defined interfaces enable interorganizational modularity and facilitate a division of labor across organizational boundaries.[114] This interorganizational standardization could potentially help to create component or systems markets between providers of different pieces of the infrastructure.

E. Tax Policy

Tax deductions or credits encourage firms to invest in R&D, but how tax incentives are structured may change the relative attractiveness of internal versus external R&D. In the typical scenario of large profitable firms buying from smaller and younger startups, as in major pharmaceutical firms buying from biotech startups, incentives that favor small firms would increase the supply of external innovations. Examples of incentives favoring small firms include caps on incentive payments per firm, as well as the use of tax credits instead of deductions (the latter being less useful for small firms that pay lower tax rates or may be unprofitable).

111. Mowery & Simcoe, *supra* note 82.

112. Joel West, *Seeking Open Infrastructure: Contrasting Open Standards, Open Source and Open Innovation*, 12 FIRST MONDAY 6 (2007).

113. Scott Bradner, *The Internet Engineering Task Force*, *in* OPEN SOURCES: VOICES FROM A REVOLUTION, *supra* note 13, at 47–52.

114. Langlois, *supra* note 40.

The attractiveness of external sources of innovation can also be affected by state policies, such as the highly controversial proposals by states to increase revenues by taxing services.[115] A state sales tax on services assessed on contract R&D would make external innovations more expensive and thus less attractive than those traded within the firm. Conversely, a tax policy that treated royalties more favorably than contract services might allow external innovation to continue unimpeded, at least for firms that anticipate tax issues in contracting for such external innovations.

CONCLUSIONS

Interorganizational innovation is a reality of the modern industrial world. We tend to think of this innovation as a recent phenomenon, born of the Internet technology that has enabled global virtual collaboration. Such collaboration, however, has been common in industrial districts for centuries, and although records are scarce, it likely existed within medieval guilds before that. That said, the combined personal computer revolution of the 1980s and the Internet revolution of the 1990s have democratized such innovation by making writing, software production, music composition, video editing, and a wide array of other creative activities available to anyone with access to a PC.[116]

In modern or medieval times, the policy tradeoffs for encouraging innovation remain the same: maximizing the incentives for specific firms or individuals to innovate while minimizing the cumulative drag on the remaining pool of potential innovators. Policy decisions need to be informed by broader and deeper empirical evidence on both sides of this tradeoff.

115. Federation of Tax Administrators, FTA Survey of Services Taxation—Update, http://www.taxadmin.org/fta/pub/services/btn/0708.html (last visited May 13, 2009).

116. *See, e.g.*, Jonathan Zittrain, *The Generative Internet*, 119 HARV. L. REV. 1974, 1974–2040 (2006).

TABLE 1: SOURCES OF INNOVATION IN CONTRASTING THEORIES OF INNOVATION

Theory	Key Author	Focal Firm	Suppliers	Customers	Rivals
Vertical integration	Alfred Chandler	X			
User innovation	Eric von Hippel	X	†	X	
Cumulative innovation	Suzanne Scotchmer	X			X
Open innovation	Henry Chesbrough	X	X	X	X

† Not emphasized by subsequent research

TABLE 2: INTERORGANIZATIONAL INNOVATION PREDICTIONS FOR IP POLICY CHANGES

Theory	Assumptions/Focus	Effect of Stronger IP Regime
Vertical integration	Firms gain advantage by controlling end-to-end innovation pipeline	Increasing returns for internal R&D
User innovation	Individuals contribute important innovations	May (or may not) interfere with user ability to create innovation
Cumulative innovation	Innovation comes from cooperation between firms in an industry	Reduces spillovers between firms; slows advance of science
Open innovation	Firms gain advantage through markets for innovation	Increases incentives for developing IP; creates markets for IP