ARTICLE

BOUNDARY-SPANNING COLLABORATION AND THE LIMITS OF JOINT INVENTORSHIP DOCTRINE

Liza Vertinsky[*]

ABSTRACT

Innovation is now, more than ever before, a collaborative pursuit. Collaboration is occurring in new ways across a variety of different boundaries, including geographical, organizational and disciplinary boundaries, the public–private divide, and even the boundary between human and machine. Patents, traditionally seen as mechanisms for enhancing collaboration, may not always function as intended in these diverse collaborative arrangements. This Article focuses on three types of boundary-spanning collaboration that occur with increasing frequency in processes of innovation: (1) user–producer innovation, (2) public–private partnerships, and (3) human–machine collaboration. It identifies some of the ways in which these types of boundary-spanning collaborations challenge, and are challenged by, the existing U.S. patent law framework. It focuses in particular on the problems that arise from trying to fit a variety of different discovery processes and participants into an inventor-centric model of invention through patent law's joint inventorship doctrine. This approach to collaborative invention ignores, rather than accommodates, the different characteristics and needs of boundary-spanning collaborations. The analysis highlights the need to take differences among participants and their

---

* Associate Professor, Emory Law School; Ph.D. (econ.) 1997, J.D. 1997 Harvard University. With special thanks to Tim Holbrook, and to Josh Sarnoff, Peter Lee, Sarah Wasserman Rajec, Sapna Kumar, Janewa Osei-Tutu, Sean Seymour, Andrew Chin, Jeremy Block, Greg Vetter and all of the other participants in the Houston IPIL National Conference held on June 2–3, 2017.

relationships with each other in processes of intellectual production—what I refer to as the social contexts of innovation—into greater account in patent law as these types of collaborations become the norm, rather than the exception.

TABLE OF CONTENTS

I. INTRODUCTION

> "Many ideas grow better when transplanted into another mind than in the one where they sprang up."[1]
>
> "[L]ike people, ideas have social lives. They're one way when they're by themselves, and another when they're surrounded by their peers."[2]

1. OLIVER WENDELL HOLMES, THE BREAKFAST TABLE SERIES: THE POET AT THE BREAKFAST TABLE 146 (1900).
2. Joshua Rothman, *A New Blog About Ideas*, THE NEW YORKER (June 4, 2014), http://www.newyorker.com/books/joshua-rothman/a-new-blog-about-ideas.

Innovation, which encompasses both invention and its transformation into goods and services, is not a discrete event and does not occur in a vacuum.[3] Rather, it is a complex process that occurs through interactions among various actors at different points in time within a particular historical, cultural, technological, and economic context.[4] It involves the combination and recombination of old and new ideas by people interacting with each other in response to constantly changing knowledge, technology, and shifting user preferences and needs.[5] Innovation is ultimately a social process,[6] shaped as much by collaboration as

---

3. *See, e.g.*, Stephen J. Kline & Nathan Rosenberg, *An Overview of Innovation*, THE POSITIVE SUM STRATEGY: HARNESSING TECHNOLOGY FOR ECONOMIC GROWTH 275, 283 (Ralph Landau & Nathan Rosenberg eds., 1986) ("[I]t is a serious mistake to treat an innovation as if it were a well-defined, homogenous thing that could be identified as entering the economy at a precise date—or becoming *available at* a precise point in time."); ANDREW H. VAN DE VEN, DOUGLAS E. POLLEY, RAGHU GARUD & SANKARAN VENKATARAMAN, THE INNOVATION JOURNEY 149 (1999) ("Popular folklore notwithstanding, the innovation journey is a collective achievement that requires key roles from numerous entrepreneurs in both the public and private sectors."); Jan Fagerberg, *Innovation: A Guide to the Literature*, Presented at The Many Guises of Innovation: What We Have Learnt and Where We Are Heading 3 (Oct. 23–24, 2003), https://smartech.gatech.edu/bitstream/handle/1853/43180/JanFagerberg_1.pdf?sequence=1&isAllowed=y (showing ties between innovation and invention) [https://perma.cc/MLA9-7PVF].

4. *See, e.g.*, STEVEN JOHNSON, WHERE GOOD IDEAS COME FROM: THE NATURAL HISTORY OF INNOVATION 21–22 (2010) (making the case that innovation occurs as the product of various combinations of events and activities that have occurred in the past and as the product of rich connections between people and ideas in institutional and cultural environments that foster the creation and diffusion of ideas and arguing that collaboration is at least as important as competition in explaining innovation); M.J. MULKAY, THE SOCIAL PROCESS OF INNOVATION: A STUDY IN THE SOCIOLOGY OF SCIENCE 47 (1972) (emphasizing importance of the relationships between research networks in the growth of scientific ideas); M. Janssen, A.M.V. Stoopendaal & K. Putters, *Situated Novelty: Introducing a Process Perspective on the Study of Innovation*, 44 RES. POL'Y 1974, 1976 (2015) (thinking of innovation as a process requires us "to acknowledge the complexity of novelty and innovation in organizations in a constantly changing world . . . [and] changes the way novelty can be analyzed in relation to innovation"); John Seely Brown & Paul Duguid, *Knowledge and Organization: A Social-Practice Perspective*, 12 ORG. SCI. 198, 199 (2001) (emphasizing the importance of the sociocultural contexts in which knowledge is generated and exploring the role of communities of practice in explaining knowledge stickiness and knowledge leakiness: knowledge is sticky where practices are not shared between organizations and leaky where they cross the boundaries of the organization); Laura G. Pedraza-Fariña, *Patent Law and the Sociology of Innovation*, 2013 WIS. L. REV. 813, 823 (2013) (emphasizing importance of social factors in explaining innovation).

5. *See, e.g.*, Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J. ECON. PERSP. 29, 29 (1991) ("Most innovators stand on the shoulders of giants, and never more so than in the current evolution of high technologies, where almost all technical progress builds on a foundation provided by earlier innovators."); Rochelle Cooper Dreyfuss, *Commodifying Collaborative Research*, *in* THE COMMODIFICATION OF INFORMATION 397, 398 (Niva Elkin-Koran & Neil Weinstock Netanel eds., 2002) (discussing changing factors in innovation, production, and creativity); Mark A. Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 713 (2012) (exploring the implications for patent law of invention as a social phenomenon).

6. *See, e.g.*, W. BERNARD CARLSON, INNOVATION AS A SOCIAL PROCESS: ELIHU

by competition.[7] The types and motivations of stakeholders, the environment in which they compete, and the nature and strength of their relationships with each other in processes of intellectual production and consumption—what I refer to in this Article as the social contexts of innovation—play critical roles in shaping innovation processes and outcomes.[8]

While this understanding of innovation as a social process has informed a vast policy literature on innovation systems, ecosystems, and networks,[9] and a similarly expansive organizational and sociological literature on the social production and diffusion of knowledge,[10] the varied social contexts and

THOMSON AND THE RISE OF GENERAL ELECTRIC, 1870–1900 14 (1991) (investigating innovation as a social process, grounded in interactions with many stakeholders and informed by technological, economic, and social context); *see also* Janssen et al., *supra* note 4, at 1976 (noting that innovation "is considered an artifact that is inherently part of social processes" and that from this point of view the concept of what it means to be novel or new is problematic); Lemley, *supra* note 5, at 715 (discussing individual-inventor bias in patent law, showing that significant new technologies are often invented simultaneously or nearly simultaneously by two or more competing teams, and suggesting that inventions are "socially derived"); Amy L. Landers, *Ordinary Creativity in Patent Law: The Artist Within the Scientist*, 75 MO. L. REV. 1, 7 (2010) (analyzing how understandings of invention as a social process driven by human creativity should inform patent law, including a review of relevant literature).

7. *See, e.g.*, JOHNSON, *supra* note 4, at 21 (arguing that collaboration is at least as important a driver of innovation as competition)*; see also* Yochai Benkler, *Law, Innovation and Collaboration in Networked Economy and Society*, 13 ANN. REV. L. & SOC. SCI. 231, 232–33 (2017) (examining shifts in innovation and theories of innovation, focusing on centrality of learning networks, mixed incentives, and the weaving of commons with property).

8. *See, e.g.*, Alex Howard, *The History of "The Innovators" Tells Us that Collaboration is Core to Innovation*, TECHREPUBLIC (Dec. 8, 2014), http://www.techrepublic.com/article/the-history-of-the-innovators-tells-us-that-collaboration-is-core-to-innovation/ [https://perma.cc/UDE9-JBAJ] (discussing conclusions Isaacson draws in *The Innovators*); WALTER ISAACSON, THE INNOVATORS 484–85 (2014) (exploring the roles of teamwork and collaboration in fostering the digital revolution)*; see also* Michal Arbilly & Kevin N. Laland, *The Magnitude of Innovation and its Evolution in Social Animals*, 284 PROC. ROYAL SOC'Y BIOLOGICAL SCI. 1, 2 (2017) (providing an understanding of the social aspects of innovation in evolutionary terms).

9. *See, e.g.*, Franz Tödtling, Patrick Lehner, & Alexander Kaufmann, *Do Different Types of Innovation Rely on Specific Kinds of Knowledge Interactions?*, 29 TECHNOVATION 59, 62 (2009) (discussing strands of literature exploring aspects of innovation as an interactive process and examining extent to which different types of innovation rely on specific types of knowledge sources and links); Benkler*, supra* note 7, at 232 (examining trend in innovation literature towards collaborative and network-based theories of innovation); Eric von Hippel, *Horizontal Innovation Networks—By and for Users*, 16 INDUS. CORP. CHANGE 293, 310 (2007) (exploring emergence of horizontal innovation networks among users); Andreas Pyka, *Innovation Networks in Economics: From the Incentive-Based to the Knowledge-Based Approaches*, 5 EUR. J. INNOVATION MGMT. 152, 158 (2002) (discussing the importance of innovation networks as organizational features in industrial organization and providing an overview of economic theories of innovation networks). For an overview of alternative innovation theories, *see* Fagerberg, *supra* note 3, at 10–11.

10. For foundational studies in the social context of scientific knowledge production, *see, e.g.*, ROBERT K. MERTON, THE SOCIOLOGY OF SCIENCE: THEORETICAL AND EMPIRICAL

networks within which innovation occurs have been largely neglected in the fashioning of patent law and policy.[11] Instead of responding to differences that may arise where inventions are the product of multiple heterogeneous collaborators, patent law seeks to fit collaborative discovery into its single inventor-centric model of invention. It handles collaborative invention primarily through its joint inventorship doctrine,[12] a doctrine anchored in the concepts of individual inventor and discrete invention and riddled with complexity.[13]

INVESTIGATIONS 7 (Norman W. Storer ed., 1973) (discussing the emergence of the study of the sociology of science); NORMAN W. STORER, THE SOCIAL SYSTEM OF SCIENCE 86 (1966) (examining how the norms of science embody the principles that govern social systems). For examples of modern studies of alternative forms of collaborative knowledge production that incorporate social context, *see generally* NEW FORMS OF COLLABORATIVE INNOVATION AND PRODUCTION ON THE INTERNET 10 (Volker Wittke & Hedemarie Hanekop, eds., 2011). Also of relevance is literature on knowledge within organizations and across organizations, cross-boundary teaming, and the importance of social capital. *See, e.g.*, Amy C. Edmondson & Jean-François Harvey, *Cross-Boundary Teaming for Innovation: Integrating Research on Teams and Knowledge in Organizations* 6 (Harv. Bus. Sch., Working Paper No. 17-013, 2017) (drawing from literature on knowledge in organizations and team production to examine complexity of cross-boundary teaming); Annika Dingler & Ellen Enkel, *Socialization and Innovation: Insights from Collaboration across Industry Boundaries*, 109 TECH. FORECASTING & SOC. CHANGE 50, 51 (2016) (examining role of socialization in supporting knowledge transfer across industry boundaries in collaborations)*; see also* Réjean Landry, Nabil Amara & Moktar Lamari, *Does Social Capital Determine Innovation? To What Extent*?, 69 TECH. FORECASTING & SOC. CHANGE 681, 684 (2002) (providing a literature review of alternative theories of innovation that explore processes of innovation and their determinants).

11. *See, e.g.*, Peter Lee, *Social Innovation*, 92 WASH. U. L. REV. 1, 25 (2014) ("[P]atent law's unique policy mechanism of assigning individual rights to inventions leads to a distorted conception of the innovative processes it seeks to promote.") A small but growing body of work exploring how the social context should inform intellectual property policies is starting to emerge, however. *See, e.g.*, Dan L. Burk, *On the Sociology of Patenting*, 101 MINN. L. REV. 421, 441 (2016) (emphasizing the need to understand intellectual property within the context of social practices and institutions); Pedraza-Fariña, *supra* note 4, at 823 (emphasizing importance of social factors in explaining innovation); Gregory N. Mandel, *To Promote the Creative Process: Intellectual Property Law and the Psychology of Creativity*, 86 NOTRE DAME L. REV. 1999, 2016 (2011) (demonstrating that psychology of creativity can inform our understanding of how IP can support or hinder creative collaborative processes); William Hubbard, *Inventing Norms*, 44 CONN. L. REV. 369, 378, 404 (2011) (suggesting that patent law has neglected the role of social norms that encourage invention); Jessica Silbey, *Heuristic Interventions in the Study of Intellectual Property*, 101 MINN. L. REV. HEADNOTES 333, 335 (2017) ("When we study law, we are studying human transactions and relationships as well as the institutional mechanisms that shape both the products and the processes of social action."); Jeanne C. Fromer, *Expressive Incentives in Intellectual Property*, 98 VA. L. REV. 1745, 1789 (2012) (exploring importance of nonpecuniary incentives in the creation of socially valuable work); Eric E. Johnson, *Intellectual Property and the Incentive Fallacy*, 39 FLA. ST. U. L. REV. 623, 640 (2012) (emphasizing importance of natural and intrinsic motivations in innovating and the need to rethink patent law in light of alternative motivations).

12. *See* Joint Inventions, 35 U.S.C. § 116(a) (2012); Application for Patent by Joint Inventors, 37 C.F.R. § 1.45.

13. *See, e.g.*, B. Chapman, *The Muddy Collaboration Element of Joint Inventorship*, LAW360 (September 20, 2010), https://www.law360.com/articles/192274/the-muddy-

In contrast to models of collaborative innovation, which emphasize the importance of knowledge flows and collective intellectual production, the patent system has its roots in a model of the lone genius who, if properly incentivized, will solve problems that have evaded existing experts.[14] For over a decade preceding the 1952 amendment of the Patent Act, federal courts searched for the "flash of genius" in their determinations of inventions.[15] The current patent law framework has not moved far from this individual-inventor paradigm. It continues to presume a market-based, producer-driven model of innovation with an individual inventor or a discrete and identifiable group of co-inventors at the center.[16] Patents provide incentives to these producer–inventors to make, disclose, and develop their inventions, and they facilitate market-based transactions between inventors and third parties interested in developing or using the inventions.[17] This approach neglects the rich social contexts in which discoveries are made, developed, used, and commercialized (or not),[18] thereby also neglecting the varied and changing roles that patents may play in these various social contexts.[19] As a

---

collaboration-element-of-joint-inventorship [https://perma.cc/GS5Q-3EEG].

14. *See, e.g.*, Lemley, *supra* note 5, at 715, 731–733 (arguing that patent law is built around the myth of the lone genius, with an individual-inventor bias in both theory and doctrine); *see also* Fritz Machlup & Edith Penrose, *The Patent Controversy in the Nineteenth Century*, 10 J. ECON. HIST. 1, 2 (1950) (exploring the debate over patents and the model of producer driven invention that ultimately dominated patent law and policy).

15. *See, e.g.*, Ryan Abbot, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law*, 57 B.C. L. REV. 1079, 1110–11 (2016) (discussing demise of the flash of genius doctrine); *see also* 35 U.S.C. § 103 (2012) ("Patentability shall not be negated by the manner in which the invention was made.").

16. *See* Lemley, *supra* note 5, at 715 (discussing individual-inventor bias in patent law)*; see also* Eric von Hippel & Jeroen P.J. de Jong, *Open, Distributed and User-Centered: Towards a Paradigm Shift in Innovation Policy*, 6–7 (SCALES, Working Paper, Feb. 2010 at http://ondernemerschap.panteia.nl/pdf-ez/h201009.pdf [https://perma.cc/F727-JHGC]) (arguing that current innovation policy ignores that innovation is increasingly open, distributed, and user-centered, relying instead on a logic of producer-centered innovation in policy formation).

17. *See* WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 328 (2003) (examining alternative theories of patents, including the traditional reward function).

18. *See, e.g.*, Lemley, *supra* note 5, at 711 (showing that significant new technologies are often invented simultaneously or nearly simultaneously by two or more competing teams and suggesting that invention "appears in significant part to be a social, not an individual, phenomenon").

19. *See, e.g.*, Mark A. Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 148 (2004) (describing competing arguments about exclusive control of information); Julien Penin, *Patents Versus Ex Post Rewards: A New Look,* 34 RES. POL'Y 641, 649 (2005) (arguing that in many industries firms use patents as mechanisms for trading technologies and supporting R&D collaborations); Stephen Yelderman, *Coordination-Focused Patent Policy*, 96 B.U. L. REV. 1565, 1572 (2016) (looking at incentivized investment as a traditional focus of invention); Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341, 365–66 (2010) (arguing literature has

result of the continued patent law reliance on this limited approach to collaborative intellectual production, patent law, and the theories that explain and inform it, have failed to keep up with the changing landscape of collaborative innovation.[20]

Responding to the needs and interests of diverse participants in processes of innovation is becoming more critical as collaborative innovation continues to increase in volume, value, and diversity.[21] Collaborations spanning organizational and disciplinary boundaries have become essential for exploring many of the most pressing research and development problems and opportunities.[22] These cross-boundary collaborations prove to be valuable sources of innovation.[23] Heterogeneous collaborations have been associated with relatively high quality inventions, suggesting the value of diversity in the innovation process.[24] Sustaining collaboration among different groups is not without challenges, however, and regulatory approaches such as the

---

neglected important effects of patents on post-invention commercialization).

20. *See, e.g.*, Benkler, *supra* note 7, at 239 (arguing that patents are optimized for an increasingly obsolete worldview as innovation trends shift); Dreyfuss, *supra* note 5, at 408–10 (examining challenges that commodification presents to collaborative projects and the disconnect between IP laws and the needs of innovators); Katherine J. Strandburg, *Intellectual Property at the Boundary*, in REVOLUTIONIZING INNOVATION: USERS, COMMUNITIES, AND OPEN INNOVATION 235, 241 (Dietmar Harhoff & Karim R. Lakhani, eds., 2016) (arguing that the boundaries between privately ordered—collaborative—innovation regimes and IP-based markets have been largely ignored but raise important issues).

21. *See, e.g.*, Dreyfuss, *supra* note 5, at 398 (examining new alignments in innovation); Strandburg, *supra* note 20, at 245 (discussing collaboration with outsiders).

22. *See, e.g.*, L. MICHELLE BENNETT ET AL., NAT'L INST. HEALTH, COLLABORATION & TEAM SCIENCE: A FIELD GUIDE 1 (2010) (noting the rise of team science and ideas for how to confront the challenges of pursuing team science collaborations and that specialization "has made interdependence, joint ownership, and collective responsibility" among scientists essential).

23. *See, e.g.*, John P. Walsh, You-Na Lee & Sadao Nagaoka, *Openness and Innovation in the U.S.: Collaboration Form, Idea Generation and Implementation*, 45 RES. POL'Y 1660, 1661 (2016) (discussing empirical study of the relationship between collaboration and innovation). *See also* Lu Hong & Scott E. Page, *Groups of Diverse Problem Solvers Can Outperform Groups of High-Ability Problem Solvers*, 101 PROC. NATL. ACAD. SCI. U.S. 16385, 16385 (2004) (showing that the functional diversity of a problem solving team contributes to value of outcomes and suggesting that projects that cross-organizational boundaries are likely to produce more valuable inventions); Aija Leiponen & Constance E. Helfat, *Innovation Objectives, Knowledge Sources, and the Benefits of Breadth*, 31 STRATEGIC MGMT. J. 224, 225 (2010) (showing the benefits of a variety of different approaches to innovation); James H. Love et al., *Learning from Openness: The Dynamics of Breadth in External Innovation Linkages*, 35 STRATEGIC MGMT. J. 1703, 1704 (2013) (discussing how obtaining broader knowledge sources can lead to more valuable innovation outcomes); Bart Nooteboom, *Learning and Innovation in Inter-Organizational Relationships, in* THE OXFORD HANDBOOK OF INTER-ORGANIZATIONAL RELATIONSHIPS 615 (Steve Cropper, Mark Ebers, Chris Huxham, & Peter Smith Ring eds., 2008) (discussing how "variety is a crucial source of innovation").

24. *See, e.g.*, Walsh et al., *supra* note 23, at 1661 ("[M]ore heterogeneous collaboration. . . will generate more. . . significant inventions.").

allocation of intellectual property rights that work well in traditional forms of market-based collaboration may not readily extend to diverse forms of collaboration.[25] While patents may facilitate collaboration in some cases and contexts, in others they may interfere with or undermine it.[26]

This Article focuses on three types of boundary-spanning collaborations that occur with increasing frequency in modern processes of innovation: (1) user–producer collaboration, (2) public–private partnerships, and (3) human–machine collaboration. It identifies some of the ways in which these types of collaborations challenge, and are challenged by, the existing patent law framework, with a particular focus on the limitations of patent law's joint inventorship doctrine to handle collaborative intellectual production.

Part II of this Article explores trends in collaborative innovation across geographical, disciplinary, organizational, and even human/machine boundaries—what I refer to here as "boundary-spanning" collaborations.[27] Part III provides three alternative collaboration paradigms and illustrates some of the tensions that emerge between these modes of innovation and the existing patent law framework. Part IV focuses on the growing disconnect between the way that patent law currently handles collective invention, primarily through joint inventorship, and the realities of boundary-spanning collaborations. It examines the challenges that this doctrine poses for modern forms of collaborative innovation and suggests why patent law change is needed.

II. PATENTS AND COLLABORATION ACROSS BOUNDARIES

> "To be successful, innovating organizations must form linkages, upstream and downstream, lateral and horizontal.

---

25. *See, e.g.*, Benkler, *supra* note 7, at 232 ("If innovation is primarily an emergent property of knowledge flows, sharing, and collective learning in communities of practice and knowledge networks, then these [incentive/access] core levers of innovation law are mostly counterproductive").

26. *See, e.g.*, Liza S. Vertinsky, *Making Room for Cooperative Innovation,* 41 FLA. ST. U. L. REV. 1067, 1095 (2014) (examining tensions that patents create for sustaining cooperative systems of innovation).

27. As defined in Part II, the term "boundary-spanning" refers to situations in which participants from two or more distinct groups with distinct modes of producing, exchanging, and using knowledge engage in cross-boundary collaboration of some kind. *See* Paul R. Carlile, *A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development*, 13 ORG. SCI. 442, 443 (2002) (discussing different approaches to moving knowledge across boundaries).

> Advanced technological systems do not and cannot get created in splendid isolation."
>
> —J. Teece [28]
>
> "As business becomes increasingly global and cross-functional, silos are breaking down, connectivity is increasing, and teamwork is seen as key to organizational success."[29]

The history of science highlights the role of the individual genius in scientific and technological discovery. Yet, upon closer examination of even the most famous examples of individual discovery, the importance of networks of interactions in producing and improving upon these discoveries becomes evident.[30] "[T]he way that great inventions and discoveries are made seems to have gravitated increasingly away from individual inventors and toward networks of people."[31] Individualistic modes of science are being replaced by teamwork production.[32] Modern scientific projects are group activities, and the groups keep getting bigger.[33]

---

28. David J. Teece, *Competition, Cooperation, and Innovation: Organizational Arrangements for Regimes of Rapid Technological Process*, 18 J. ECON. BEHAV. ORG. 1, 22–24 (1992) (suggesting that U.S. policymakers have failed to recognize the importance of cooperation in innovation and predicting the rise of new hybrid organizational arrangements); John Bessant, *Knowledge as a Social Process*, ISPIM (Feb. 8, 2017), https://www.ispim-innovation.com/single-post/2017/02/01/John-Bessant-Knowledge-as-a-social-process [https://perma.cc/S9YS-YAEC] (discussing critical role of social aspects of innovation process); John Bessant, *Creating the Physical Space for Innovation*, HYPE INNOVATION BLOG (Sept. 7, 2016, 5:00:00 AM), http://blog.hypeinnovation.com/creating-spaces-for-innovation [https://perma.cc/UBK5-4NDF] (exploring the critical role of creating spaces that attract diverse people and organizations to co-create).

29. Rob Cross, Reb Rebele & Adam Grant, *Collaborative Overload*, 94 HARV. BUS. REV. 74, 76 (2016) (noting the growing importance of collaboration but that collaboration is not always appropriately rewarded).

30. *See, e.g.*, Lemley, *supra* note 5, at 715–16 (arguing important inventions were result of gradual processes incorporating multiple inventors); Robert C. Allen, *Collective Invention,* 4 J. ECON. BEHAV. ORG. 1, 3 (1983) (discussing collective invention); James Bessen & Alessandro Nuvolari, *Knowledge Sharing among Inventors: Some Historical Perspectives*, at 3 (B.U. Sch. L., Working Paper No. 11-51, 2011) (discussing importance of collective invention in the nineteenth century); JOHNSON, *supra* note 4, at 61 ("[T]he most productive tool for generating good ideas remains a circle of humans at a table, talking shop.").

31. *The Key Lessons from "Where Good Ideas Come From" by Steven Johnson: About the Natural History of Innovation*, BLINKIST MAG. (Nov. 27, 2013), https://medium.com/key-lessons-from-books/the-key-lessons-from-where-good-ideas-come-from-by-steven-johnson-1798e11becdb [https://perma.cc/KG3Z-TT6C].

32. *See* Stefan Wuchty, Benjamin F. Jones & Brian Uzzi, *The Increasing Dominance of Teams in Production of Knowledge*, 316 SCI. 1036, 1036 (2007) (using examination of paper-patent pairs to demonstrate that teams increasingly dominate solo authors in knowledge production, including high impact research).

33. *See, e.g.*, You-Na Lee, John P. Walsh & Jian Want, *Creativity in Scientific Teams: Unpacking Novelty and Impact*, 44 RES. POL'Y 684, 694 (2015) (showing science is increasingly a team endeavor and highlighting need for governance approach to scientific work); James D. Adams et al., *Scientific Teams and Institutional Collaborations: Evidence*

The trend towards team invention and collective co-creation is illustrated by the steady trend over the past few decades towards the listing of multiple inventors on patents and monotonic increases in the number of co-authors on scientific papers.[34] Moreover, these teams often operate within scientific networks that benefit from the ideas of competing teams. Discoveries frequently emerge in situations where multiple groups are struggling with the same problem and reaching the same general solution at roughly the same time, resulting in near-simultaneous independent discovery.[35]

The increase in collaborative intellectual production is not isolated to the realm of scientific discovery, but is occurring in other areas such as engineering and the social sciences.[36] Research teams are spanning numerous organizational and disciplinary boundaries to pursue innovation.[37] Indeed, teams are often formed precisely to gain diversity, seeking to cultivate and benefit from the cross-pollination of ideas among individuals with different training, backgrounds, ideas and capabilities.[38] "Creativity is spurred when proven innovations in one domain are introduced into a new domain, solving old problems and inspiring fresh thinking."[39] New ideas often come from cross-overs between different knowledge communities, emerging "from selection and synthesis across the structural holes between groups."[40] A number of empirical studies have suggested that some of the highest value research is coming from teams that cross disciplinary,

---

from U.S. Universities, 1981–1999, 34 RES. POL'Y 259, 282 (2005) (showing trend towards larger and more geographically dispersed scientific teams over time).

34. *See* Dennis Crouch, *Charting Inventorship: Teams Get the Prize*, PATENTLY O BLOG (May 6, 2016), https://patentlyo.com/patent/2016/05/charting-inventorship-prize.html [https://perma.cc/EF63-WLNY] (pointing out that more than half of US patents listed multiple inventors by around 1990 with that trend continuing; Roger Guimerà et al., *Team Assembly Mechanisms Determine Collaboration Network Structure and Team Performance*, 308 SCI. 697, 697 (2005) (showing increase in team size in scientific fields over time and value of teams that are formed among disparate sets of collaborators).

35. *See* Lemley, *supra* note 5, at 713 (exploring simultaneous discovery).

36. *See, e.g.*, Wuchty et al., *supra* note 32, at 1036 (using examination of paper-patent pairs to demonstrate that teams increasingly dominate solo authors in knowledge production, including high impact research).

37. *See, e.g.*, Edmondson et al., *supra* note 10, at 6 (examining cross-boundary teaming and team diversity).

38. *See* Guimerà, *supra* note 34, at 697 (showing balance of diversity needed by teams).

39. *See* Guimerà, *supra* note 34, at 697*; see also* Brian Uzzi & Jarrett Spiro, *Collaboration and Creativity: The Small World Problem*, 111 AM. J. SOC. 447, 448 (2005) (examining small world network effects on creativity).

40. *See, e.g.*, Ronald S. Burt, *Structural Holes and Good Ideas*, 110 AM. J. SOC. 349, 350 (2004) (explaining how brokering relationships across structural holes between knowledge groups can translate into social capital that supports innovation).

organizational, and national boundaries, providing support for the view that diversity in collaborations can yield innovation gains.[41]

This pervasive shift towards boundary-spanning collaboration suggests "that the process of knowledge creation has fundamentally changed."[42] The change is not limited to early stages of research, but is also occurring in downstream development and in the commercialization of discoveries. In the face of rapid technological change, complex scientific and technological problems, rising costs, and sharpening competition, private companies have turned with greater frequency to collaborative arrangements with both public and other private organizations to support all aspects of research, development, and commercialization.[43] To stay in business, organizations search for ways of sharing cost and risk, and they take advantage of opportunities to specialize in ways that force them also to rely on inputs from other companies—resulting in what is now widely known as a trend towards more "open innovation."[44] There is an expansion of private sector relationships based on partnership rather than ownership,[45] and a variety of informal innovation networks among companies have emerged.[46]

---

41. *See, e.g.*, Jonathan Adams, *Collaborations: The Rise of Research Networks*, 490 NATURE 335, 336 (2012) (examining implications of growth in regional collaboration); Wuchty et al., *supra* note 32, at 1036–37 (looking at study that demonstrates that teams increasingly dominate single authors in the production of knowledge, including high-impact knowledge). For an overview of research on how different dimensions of diversity impact team output, *see* Aparna Joshi & Hyuntak Roh, *The Role of Context in Work Team Diversity Research: A Meta-Analytic Review*, 52 ACAD. MGMT. J. 599, 618 (2009), and for a case study on diversity and the emergence of a new scientific field, *see* Alina Lungeanu & Noshir S. Contractor, *The Effects of Diversity and Network Ties on Innovations: The Emergence of a New Scientific Field*, 59 AM. BEHAV. SCIENTIST 548, 558 (2015) (showing importance of diversity of knowledge in innovation).

42. Wuchty et al., *supra* note 32, at 1036.

43. *See, e.g.*, Howard E. Aldrich & Toshihiro Sasaki, *R&D Consortia in the United States and Japan*, 24 RES. POL'Y 301, 302 (1995) (examining public and private shift towards collaborative R&D in the U.S. and Japan); Ashish Arora, Wesley M. Cohen & John P. Walsh, *The Acquisition and Commercialization of Invention in American Manufacturing: Incidence and Impact*, 45 RES. POL'Y 1113, 1124–25 (2016) (showing that external sources of innovation make a significant contribution to the overall rate of innovation and that innovation policies need to pay attention to efficiency of mechanisms impacting relationships between inventors and innovators).

44. Open innovation has been defined in a variety of ways, but at a very broad level it refers simply to organizations relying on external as well as internal knowledge to innovate. *See, e.g.*, HENRY W. CHESBROUGH, OPEN INNOVATION: THE NEW IMPERATIVE FOR CREATING AND PROFITING FROM TECHNOLOGY xxiv (2003).

45. *See, e.g.*, Andrew C. Inkpen, *Creating Knowledge through Collaboration*, 39 CAL. MGMT. REV. 123, 125 (1996) (examining mechanisms for exploiting collaborative knowledge in firms).

46. *See, e.g.*, Ariel Porat & Robert Scott, *Can Restitution Save Fragile Spiderless Networks?*, 8 HARV. BUS. L. REV. 1, 5 (forthcoming 2018) (examining increase in business networks and role law can play in the functioning of inter-firm relationships needed to

The public sector is an active participant in many such R&D partnerships and networks not just as a funder, but also as an active participant in R&D projects.[47] Public–private technology partnerships became a favored strategy for supporting applied research and its commercialization in the 1990s, resting upon the legislative groundwork for technology transfer from the public to the private sector laid in the 1980s.[48] Since then, government–industry R&D partnerships that are focused on commercializing innovations have continued to figure prominently in federal and state innovation policies, particularly in areas of public importance such as health, energy, and national security.[49] In many cases the government is taking on aspects of risk and engaging in development activities that move it outside of the traditional paradigm of government as addressing market failures and private sector as the source of entrepreneurial risk and results.[50] Recent examples include the Accelerating Medicines Partnership, in which the National Institute of Health and private companies pool knowledge and money in efforts to advance drug discovery and development in four disease areas,[51] as well as a series of collaborative manufacturing initiatives that fall under

---

sustain such networks); Olav Sorenson, *Innovation Policy in a Networked World*, 2–3 (NBER, Working Paper, 2017).

47. *See, e.g.*, Albert Link, *Government as Entrepreneur: Reframing a Dimension of Science and Technology Policy*, 39 RES. POL'Y 565, 565 (2010) ("[G]overnment acts as entrepreneur in the provision of technology infrastructure when its involvement is both innovative and characterized by entrepreneurial risk (i.e., uncertainty)."); *see also* Jorge Contreras & Liza Vertinsky, *Pre-Competition*, 95 N. C. L. REV. 67 (2016) (explores growing role of collaborations, including government-industry collaborations, in the biopharmaceutical sector).

48. *See, e.g.*, Joseph E. Stiglitz & Scott J. Wallsten, *Public-Private Technology Partnerships*, 43 AM. BEHAV. SCI. 52, 52–53 (1999) (critical examination of public-private technology partnerships in the U.S.).

49. *See, e.g.*, National Science Board, 1 SCIENCE AND ENGINEERING INDICATORS 2002, Chapter 4, Research Alliances: Trends in Industry, Government and University Collaboration, 174, 177, 179 (2002); *see also* Elias Zerhouni, *The NIH Roadmap*, 302 SCI. 63, 64 (2003) (showing the role of public-private partnerships as part of biomedical innovation roadmap).

50. *See, e.g.*, MARIANA MAZZUCATO, THE ENTREPRENEURIAL STATE: DEBUNKING PUBLIC VS. PRIVATE SECTOR MYTHS 4, 6, 12 (2015) (explores the important role of the government, and government funds, in creating technologies behind the internet, GPS, fracking, and algorithmic search; argues that the public sector takes most of the risks but does not adequately share in the rewards).

51. *See, e.g.*, Aaron Kesselheim & Yongtian Tan, *Accelerating Medicines Partnership: A New Public-Private Collaboration for Drug Discovery*, HEALTH AFFAIRS BLOG (Apr. 8, 2014), http://healthaffairs.org/blog/2014/04/08/accelerating-medicines-partnership-a-new-public-private-collaboration-for-drug-discovery/ [https://perma.cc/XS9Z-BVH7] (first national cross-sector partnership of its size and scale, reflects efforts to encourage new forms of public-private collaboration to accelerate innovation).

the umbrella of the National Network for Manufacturing Innovation.[52]

Along with multidisciplinary collaborations and public–private partnerships, another trend that is altering the innovation landscape is the growth in open user and collaborative innovation.[53] Advances in technology that lower costs and increase the speed of communication have enabled a wide variety of decentralized, distributed forms of collective innovation that are user-centered and user-driven.[54] An expanding number of empirical studies have documented the significant range of novel products and processes that are developed by users for their own use, as well as the growing importance of open collaborative innovation among users as a source of new ideas, products, and services.[55] As open collaborative models have emerged, so too have hybrid models of private and open collaborative production,[56] as well as related models of user–producer co-creation.[57] Many contemporary open source software projects, for example, involve

---

52. *See, e.g.*, THE PEW CHARITABLE TRUSTS, PUBLIC-PRIVATE PARTNERSHIPS GIVE THE UNITED STATES AN EDGE IN MANUFACTURING (2015), *available at* http://www.pewtrusts.org/~/media/assets/2015/02/hubs_fact_sheet_final.pdf [https://perma.cc/J394-8QRY] (describing some federal-private sector partnerships to encourage innovation in manufacturing).

53. *See, e.g.*, Carliss Baldwin & Eric von Hippel, *Modeling a Paradigm Shift: From Producer Innovation to User and Open Collaborative Innovation*, 22 ORG. SCI. 1399, 1399 (2011) (exploring growing importance of innovations by single-user individuals or firms and open-collaborative innovation, concluding that these models increasingly compete with, and may displace, producer driven innovation).

54. *See, e.g.*, YOCHAI BENKLER, THE WEALTH OF NETWORKS: HOW SOCIAL PRODUCTION TRANSFORMS MARKETS AND FREEDOM 60, 94–95, 143–44 (2006) (describing emerging model of commons-based peer production, characterized by weak property rights and importance of intrinsic rather than extrinsic (monetary) incentives; poses this mode of social production as an alternative to markets and hierarchy); ERIC VON HIPPEL, DEMOCRATIZING INNOVATION 1–3 (2006) (examining emerging systems of user-centered innovation and describes free innovation paradigm in which consumers are self-rewarded for their efforts and give away their innovations for free); ERIC VON HIPPEL, FREE INNOVATION 1–2 (2016) (describing free innovation paradigm in which consumers are self-rewarded for their efforts and give away their innovations for free).

55. *See, e.g.*, Baldwin & Hippel, *supra* note 53 at 1400. (summarizing some of the work showing the growth in user innovation).

56. *See, e.g.*, Eric von Hippel & Georg von Krogh, *Open Source Software and the "Private-Collective" Innovation Model: Issues for Organization Science*, 14 ORG. SCI. 208, 209–10, 212 (2003) (describing evolution of the private-collective model and the co-existence of incentives for private and collective action).

57. *See, e.g.*, Frank Piller et al., *Customer Co-Creation: Open Innovation with Customers*, in NEW FORMS OF COLLABORATIVE INNOVATION AND PRODUCTION ON THE INTERNET 31, 32, 37–38 (Volker Wittke and Heidemarie Hanekop eds., 2011) (providing a typology of methods of customer co-creation in innovation); Eric von Hippel & Christina Raasch, *Modeling Interactions between User and Producer Innovation: User-contested and User-complemented Markets for Innovations: Impacts on Market Outcomes and Social Welfare*, 14–15 (2012) (paper presented at DRUID 2012) (*available at* http://www.kites.unibocconi.it/wps/allegatiCTP/vonHippel.pdf [https://perma.cc/V234-JMJH]).

the integration of private and collective modes of innovation,[58] incorporating producers and users and a mix of different proprietary and open source strategies.[59]

There remains a strong spatial component to many collaborations reflecting the reduced transaction costs and the increased ability to share tacit knowledge as well as the likelihood of being in the same social, academic and institutional networks.[60] But other types of proximity–organizational, cognitive, and technological– increasingly support collaborations across longer physical distances. Collaborations that cross national borders are on the rise,[61] as reflected in the number of patents that include cross-border inventors.[62] Recent studies show that global teams of inventors are fairly common in U.S. public companies, as a share of their overseas activities and that global teams on patents owned by U.S. public firms are increasing.[63] The data on international co-invention suggests a move towards an "expanded international division of labor within global R&D networks."[64] "Networks of research collaboration are expanding in every region of the globe."[65]

---

58. *See, e.g.*, Hippel & Krogh, *supra* note 56, at 213 (suggesting open source software projects are best understood as examples of private-collective innovation). For an example of such a model, *see, e.g.*, Matthias Stuermer et al., *Extending Private-Collective Innovation: A Case Study*, 39 R&D MGMT. 170, 173 (2009) (examines the well-researched case of the Nokia Internet Tablet, which involves both proprietary and open source software development).

59. *See, e.g.*, Joel West, *How Open Is Open Enough? Melding Proprietary and Open Source Platform Strategies*, 32 RES POL'Y 1259, 1259–60 (2003) (exploring hybrid open source-proprietary strategies in software platforms and tradeoff between appropriation and adoption).

60. *See, e.g.*, Neil Savage, *Applying Local Knowledge*, 539 NATURE S21, S23–24 (2016) (examining factors driving high number of collaborations between top performing institutions in the same city).

61. *See, e.g.*, Adams, *supra* note 41, at 335–36 (discussing new, increasingly global collaboration patterns); Nadia El-Awady, *Shared Knowledge is Key to a Kingdom*, 532 Nature S16, S18 (2016) (international collaborations is producing both major breakthroughs and an increase in quality output).

62. *See, e.g.*, Dennis Crouch, *Cross-Border Inventors*, PATENTLY-O (Nov. 21, 2010), https://patentlyo.com/patent/2010/11/cross-border-inventorts.html [https://perma.cc/XNE8-PVDN] (patents with a US inventor had an 8% rate of including a cross-border inventor based on 2010 numbers).

63. *See, e.g.*, Sari Pekkala Kerr & William Kerr, *Global Teams for Inventive Work*, CEPR'S POLICY PORTAL (Dec. 12, 2015), http://voxeu.org/article/global-teams-inventive-work [https://perma.cc/DS8F-UXKL] (global teams on patents rose from 6% of US public firm patents in 1982 to 13% in 2004 and account for a substantial portion of observed overall growth in inventive activity).

64. L. Branstetter, G. Li, & F. Veloso, *The Globalization of R&D: China, India, and the Rise of International Co-Invention* at 1 (2013), *available at* http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.564.4629&rep=rep1&type=pdf [https://perma.cc/X6GL-9XRF].

65. Adams, *supra* note 41, at 335 ("New regional networks are reinforcing the competence and capacity of emerging research economies, and changing the global balance

The growing cross-boundary diversity in innovation processes appears to have yielded important innovation gains.[66] Studies show that collaboration across organizational and disciplinary boundaries produce higher invention quality,[67] and that collaborations across disciplines can yield unforeseen benefits.[68] Studies also reveal that international collaborations produce some of the highest quality research.[69] The tremendous value of harnessing diverse motivations and ideas through user and peer production models of innovation is only now starting to be measured.[70]

While recognizing the value of engaging diverse knowledge communities in collaborative innovation, it is also important to acknowledge the costs and challenges of seeking to move knowledge across boundaries, especially in novel settings.[71] There

---

of research activity"; noting upward trend in multi-authorship, with some papers including more than 1,000 authors; asks whether global collaboration could blend objectives in ways that risk leaving skewed priorities).

66. *See, e.g.*, Edmondson, *supra* note 10 ("Knowledge diversity expands the range of perspectives that teams can draw upon to innovate."); J. Cummings and S. Kiesler, *Collaborative Research Across Disciplinary and Organizational Boundaries*, 35 SOC. STUDIES OF SCIENCE 703 (2005) (discussing value of multi-disciplinarity and exploring tension between benefits to innovation of working across disciplinary and organizational boundaries and risks that arise from costs of coordination and relationship development).

67. *See* Walsh, et al., *supra* note 23, at 1661–62, 1669 (based on US data, finding that about 10% of inventions involve an external co-inventor and about 25% involve external (non-coinventor) collaboration, heterogeneity related to higher invention quality and higher commercialization rates; summarizes research showing that more heterogeneous collaboration (i.e. higher diversity in types of collaborators) generates more technically novel or significant inventions).

68. *See* Roger Kneebone, *Discovery Through Doing*, 542 NATURE 294, 294 (2017) (exploring unusual collaborations between lacemakers, glass artists, percussionists and medical researchers; argues that "conditions for serendipitous encounters must be deliberately curated").

69. *See* Nicky Phillips, *Nature Index 2016: Collaborations*, 539 NATURE S1, S1 (2016) (examines some of the most fruitful research collaborations, notes benefits of international partnerships, role not just of geography but also expertise, social networks, and previous interaction); Jonathan Adams, *Collaborations: The Fourth Age of Research*, 497 Nature 557, 557–59 (2013) (analyzes scientific papers and finds that the best science comes from international collaborations).

70. *See* Benkler, *supra* note 7, at 27.6 (describing peer production's important role in the modern marketplace and its growing recognition in economic research).

71. While teaming across knowledge boundaries offers value, it also creates challenges that increase with the differences between the groups. *See, e.g.*, Edmondson, *supra* note 10, at 3–4 (exploring challenges of integrating diverse knowledge across knowledge boundaries in context of cross-boundary teams); Victor P. Seidel & Siobhan O'Mahony, *Managing the Repertoire: Stories, Metaphors, Prototypes, and Concept Coherence in Product Innovation*, 25 ORG. SCI. 691, 691–92 (2014) (exploring challenge of how to coordinate many minds in the design of a single product and the challenges of ensuring common understandings); Paul R. Carlile, *Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries*, 15 ORG. SCI. 555, 558 (2004); Guimerà, *supra* note 34 at 697, 701 (examining tradeoff between benefits of diversity and costs of conflict, miscommunication, and other costs of

are a variety of costs involved in creating and sustaining collaborations crossing one or more of the boundaries discussed above that need to be weighed against the benefits, including costs of conflict, miscommunication, and higher costs of coordination.[72] In addition, while heterogeneity of contributors may lead to higher value invention by increasing the breadth of knowledge, it can also make it harder to integrate this knowledge for purposes of commercialization.[73]

> [I]mplementing an invention into an interdependent system of production requires matching the invention to existing routines, capabilities[,] and equipment, as well as modifying existing processes to accommodate the invention. This process is fraught with difficulties, and experts suspect that inventions that more closely target the existing routines or readily acquired complementary capabilities are more likely to be commercialized.[74]

Innovation policies in general, and patent policies in particular, need to take more explicit account of the factors that support and impede successful collaborations among diverse groups as the innovation landscape shifts towards more heterogeneous and collaborative forms of innovation.[75] In fashioning a patent policy response, patent policymakers consider: (1) when and how existing patent law may impede heterogeneous collaborations; and (2) how changes to patent law may reduce or overcome barriers to, or otherwise facilitate, productive forms of heterogeneous collaboration. I argue that the beginning point for this analysis should be a re-examination of joint inventorship

---

group coordination).

72. *See, e.g.*, Guimerà, *supra* note 34, at 697, 701 (discussing how diversity can increase creativity but also spur conflict and miscommunication, size involves balancing costs and benefits of increasing diversity in team); Cummings, *supra* note 66, at 704 ("There is tension between the benefits to innovation of working across disciplinary and organizational boundaries versus the risks that arise from the costs of coordination and relationship development in these collaborations;" this frames a tradeoff between innovation opportunities and coordination costs).

73. Walsh, et al., *supra* note 23, at 1662.

74. *Id*.

75. *See, e.g.*, Teece, *supra* note 28, at 2–3 (emphasizing the neglect of nonmarket forms of cooperation by policymakers and the need for complex forms of cooperation among firms to support competition and innovation). *See also* Jakob Edler et al., *The Intersection of Intellectual Property Rights and Innovation Policy Making—A Literature Review*, WIPO (July 2015), http://www.wipo.int/edocs/pubdocs/en/wipo_report_ip_inn.pdf [https://perma.cc/ZLT4-PHNT] (highlighting need to better integrate patent policies with innovation policies based on a better understanding of how patents operate in different innovation contexts, such as clusters and open innovation systems).

doctrine and its use as the main vehicle for accommodating collaborative intellectual production within patent law. In Part III, I provide examples of three different paradigms of boundary-spanning collaboration and suggest ways in which the current patent law framework may be in tension with the modes of intellectual production these paradigms rely upon. In Part IV, I examine the limitations of patent law's joint inventorship doctrine as the primary way of accommodating the discoveries that emerge from boundary-spanning collaborations. This analysis illustrates the disconnect between the model at the heart of patent law and the realities of collaborative intellectual production.

III. THREE COLLABORATION PARADIGMS

> "As researchers dive ever deeper into the realms of immense complexity, the need for pooling brainpower and resources will only increase."[76]

> "[W]e are often better served by connecting ideas than we are by protecting them."[77]

Challenges to the patent law framework emerge when collaborative innovation diverges from the model underlying the reward theory of invention—a model in which one or a small group of identifiable inventors create a discrete, novel invention for purposes of commercialization either directly or through license or sale of patent rights to product developers. Fashioning a patent law response is hindered by the lack of concepts and doctrines within patent law that can adequately capture and respond to different kinds of collaborative intellectual production.

Drawing from the organizational literature on boundary-spanning in the production of knowledge, I use the term "boundary-spanning" to denote situations involving participants from two or more distinct groups with distinct modes of producing, exchanging, and using knowledge.[78] Boundary-spanning collaborations encompass knowledge-sharing arrangements between two or more people or entities that work in different knowledge communities—whether it be in different types of organizations (public versus private or university versus

---

76. Nicky Phillips, *Index 2016: Collaborations*, 539 NATURE S1, S1 (2016).

77. JOHNSON, *supra* note 4, at 22.

78. While I draw from the organizational literatures on knowledge boundaries and boundary-spanning, the term is used here simply to relate to the combining of distinctly different modes of intellectual production that involve some combination of differences in language, meaning, motivations, and incentives. *See, e.g.*, Carlile, *supra* note 27, at 442 (viewing knowledge as local, embedded, and invested within distinct functional units, and looking at problems that arise during sharing of knowledge across boundaries between these units).

industry), different countries, different disciplines (such as science and the humanities), or different cultures (academic versus industry, open source communities versus traditional firms).[79] Boundaries may take the form of formal rules, such as the legal boundaries of a corporation, or may be informal, such as the shared organizing principles and practices of an open source community.[80] This section examines three paradigms of boundary-spanning collaboration: user–producer innovation, public–private partnerships, and machine–human collaboration. It illustrates some of the tensions that can emerge between these modes of innovation and the existing patent law framework with its limited approach towards collaborative invention.

A. *User–Producer Collaboration*

Some of the most important avenues for collaboration, as well as the locations of much tension, are occurring in areas of collaboration and conflict between proprietary producer driven modes of innovation and open collaborative communities—particularly communities of users.[81] While traditional theories of innovation have concentrated primarily on producers, a growing body of literature on user innovation has demonstrated that user communities are important sources of innovation.[82] User innovation can be roughly defined as firms or consumers that expect to benefit from using the design, product, or service that they develop, in contrast to producers that expect to benefit from selling their product or service for use by somebody else.[83] User innovation is facilitated by increases in the digitization of

---

79. For a discussion of knowledge communities and alternative terminology, *see, e.g.*, Lars Lindkvist, *Knowledge Communities and Knowledge Collectivities: A Typology of Knowledge Work in Groups*, 42 J. OF MGMT. STUD. 1189, 1191–92 (2005); Etienne Wenger, *Communities of Practice and Social Learning Systems*, 7 ORG. 225, 232 (2000) (exploring the structure and boundaries of communities of practice in the context of social learning systems).

80. Lindkvist, *supra* note 79, at 1194.

81. Strandburg, *supra* note 20, at 241–44.

82. *See, e.g.*, Glen L. Urban & Eric von Hippel, *Lead User Analyses for the Development of New Industrial Products*, 34 MGMT. SCI. 569, 570 (1988) (developing concept of lead user as innovator); HIPPEL, *supra* note 54, at 1–4; Eric von Hippel, *Economics of Product Development by Users: The Impact of "Sticky" Local Information*, 44 MGMT. SCI. 629, 640–41 (1998) (examining how agency-related costs and information-transfer costs tend to drive centers of innovation toward user communities); Piller, *supra* note 57, at 37–38 (providing a typology of methods of customer co-creation in innovation); A. W. Ulwick, *Turn Customer Input into Innovation*, 80 HARV. BUS. REV. 91, 92, 97 (2002); Stefan Thomke & Eric von Hippel, *Customers as Innovators: A New Way to Create Value*, 80 HARV. BUS. REV. 74, 74 (2002) (describing how some companies increase product value by accepting and encouraging user-led innovation).

83. Hippel & Jong, *supra* note 16, at 5.

production and the availability of low cost communication.[84] Examples of user innovation communities include video game players who add content to the games they play, sports enthusiasts who improve upon or design new sports equipment, patient advocacy groups that pursue avenues for cures to address the needs of their constituents, and manufacturers who design new and better tools and processes for their own use.[85] User innovation has been shown to dominate as a source of innovation in areas as diverse as scientific instruments,[86] semiconductor and electronic subassembly processes,[87] and innovations designed to help patients dealing with rare diseases and chronic needs.[88]

User innovation may take the form of individual users, many of whom share their innovations openly with a user community, or open collaborative communities of users involved in co-creation.[89] Open collaborative innovation refers to innovation processes in which participants contribute freely to shared products, typically working either on small projects transparent to all participants or on separate modules within a larger project.[90] Open source software projects are good examples of open collaborative user

84. *See, e.g.*, Baldwin & Hippel, *supra* note 53, at 1399. (analyzing the design and communication costs associated with single-user and open collaborative models of innovation).

85. Yuko Aoyama & Hiro Izushi, *User-Led Innovation and the Video Game Industry* at 3, 7 (IRP Conference, Working Paper, May 2008); Carliss Baldwin, Christoph Hienerth & Eric von Hippel, *How User Innovations Become Commercial Products: A Theoretical Investigation and Case Study*, 35 RES. POL'Y 1291, 1294 (2006); Wouter Boon & Ria Broekgaarden, *The Role of Patient Advocacy Organisations in Neuromuscular Disease R&D—The Case of the Dutch Neuromuscular Disease Association VSN*, 20 NEUROMUSCULAR DISORDERS 148, 148–49 (2010); Eric von Hippel, *Transferring Process Equipment Innovations from User-Innovators to Equipment Manufacturing Firms*, 8 R&D MGMT. 13, 16–18 (1977).

86. *See* Eric von Hippel, *The Dominant Role of Users in the Scientific Instrument Innovation Process*, 5 RES. POL'Y 212, 220 (1976) (summarizing the predominance of user-led innovation in scientific instrument development).

87. *See, e.g.*, Eric von Hippel, *Transferring Process Equipment Innovations from User-Innovators to Equipment Manufacturing Firms*, 8 R&D MGMT. 13, 20 (1977).; Eric von Hippel, *The Dominant Role of the User in Semiconductor and Electronic Subassembly Process Innovation*, EM-24 IEEE TRANSACTIONS ENGINEERING MGMT. 60, 60, 62, 66 (1977).

88. *See* Pedro Oliveira, Leid Zejnilovic, Helena Canhao & Eric von Hippel, *Innovation by Patients with Rare Diseases and Chronic Needs*, 10 ORPHANET J. RARE DISEASES 41, 44 (2015).

89. *See* Baldwin & Hippel, *supra* note 53, at 1404–06 (examining economic viability of producer versus single user and open collaborative innovation projects).

90. *See, e.g.*, Carliss Y. Baldwin & Kim B. Clark, *The Architecture of Participation: Does Code Architecture Mitigate Free Riding in the Open Source Development Model?*, 52 MANAGEMENT SCIENCE 1116, 1116 (2006); Baldwin & Hippel, *supra* note 53, at 1403 (defining open collaborative innovation projects as involving "contributors who share the work of generating a design and also reveal the outputs of their individual and collective design efforts openly for anyone to use").

innovation.[91] Many types of open collaborative user innovation are driven by users who make private investments in innovation that is shared as a public good, modes of innovation that have been described as private–collective innovation.[92]

A critical difference between producer and user driven innovation is the source of rewards for participating in the innovation process. In producer driven innovation, producers seek to identify and respond to user/customer needs through the market place, offering goods and services for sale in return for market rewards.[93] In user innovation, by contrast, the user benefits directly from the innovation and, in many cases, also benefits from the free sharing of the innovation with other users, without the need for a further reward.[94] Users most frequently either openly reveal their innovations or, if they don't take actions to reveal, also do not take actions to protect their innovations from disclosure and use.[95]

While free revealing of innovations challenges the traditional story of market-driven innovation and its reliance on market-based incentives, it can be explained in economic terms once difficulties in protecting innovations and private benefits from revealing are taken into account.[96] Free revealing allows other users to access the innovation to either use it or improve upon it through a peer-to-peer diffusion process.[97] The

---

91. Hippel & Krogh, *supra* note 56, at 211.

92. *See, e.g.*, *id.* at 213, 215 (combining of private investment and collective-action innovation model explains creation of public goods through private funding); Eric von Hippel & Georg von Krogh, *Free Revealing and the Private-Collective Model for Innovation Incentives*, 36 R&D MGMT. 295, 304 (2006); Simon Gachter et al., *Initiating Private-Collective Innovation: The Fragility of Knowledge Sharing*, 39 RES. POL'Y 893, 894 (2010).

93. *See, e.g.*, Hippel & Jong, *supra* note 16, at 9.

94. *See, e.g.*, Dietmar Harhoff et al., *Profiting from Voluntary Information Spillovers: How Users Benefit by Freely Revealing Their Innovations*, 32 RES. POL'Y 1753, 1754–57 (2003) (exploring the incentives that users might have to freely reveal their proprietary innovations); von Hippel, *supra* note 91, at 212–13 (contrasting the private and collective action model with emergence of hybrid private-collective models of innovation); *see also* Ruth Maria Stock et al., *Impacts of Hedonic and Utilitarian User Motives on the Innovativeness of User-Developed Solutions*, 32 J. PRODUCT INNOVATION MGMT. 308, 394 (2015) (users are rewarded by the use value of what they are creating); Ruth Maria Stock, et al., *Impacts of Personality Traits on Consumer Innovation Success*, 45 RES. POL'Y 757, 758, 763–64 (2016) (examining both national surveys that show there are tens of millions of free innovators in six countries surveyed and traits associated with successful free innovation).

95. *See* Hippel et al., *supra* note 57, at 12 (examining the effect of user innovation and peer-to-peer sharing on market dynamics).

96. *See* Baldwin & Hippel, *supra* note 53, at 1401 (providing economic rationale for free revealing, including benefits from improvements made by others, reputation, and positive network effects).

97. Hippel & Jong, *supra* note 16, at 9.

relationships between producers and users in innovation systems will vary, with some producers viewing user innovation communities as a threat while others benefit from both formal and informal collaboration with user communities.[98] In some cases competition will dominate, while in other cases user innovation will complement producer innovation either informally or formally through processes of co-creation.[99] Peer-to-peer modes of diffusion within user communities are most likely to emerge where communication costs are low relative to design costs, the design project is separable into modules that allow for simultaneous distributed design, and where the design itself is a nonrival good.[100] User innovations also tend to occur earlier in the development process, and user-innovators often make their innovations available without intellectual property protections.[101] Producer innovations are more often concentrated in improvements to products and services of known function serving larger markets, and intellectual property protection is often used to extract market rents as the reward for the innovations.[102]

User and producer communities also diverge in the types of knowledge that they use and produce. "Users and producers tend to know different things and accordingly employ different knowledge in the innovation process."[103] Users have better information about their needs and changing contexts of use, often possessing sticky localized knowledge that is difficult to transfer.[104] User innovation thus often concentrates in specialized production, with high variable cost, low capital production methods.[105] Producers typically have better design and marketing capabilities that allow them to incrementally improve on existing needs to satisfy larger markets.[106] In some cases producers will enter user-created markets with high capital, low variable cost

98. *See, e.g.*, Alfonso Gambardella et al., *The User Innovation Paradigm: Impacts on Markets and Welfare*, MGMT. SCI. 2 (2016).

99. *See, e.g.*, Hippel & Raasch, *supra* note 57, at 2, 6, 10, 12, 14, 16.

100. *See, e.g.*, Carliss Y. Baldwin & Kim B. Clark, *The Architecture of Participation: Does Code Architecture Mitigate Free Riding in the Open Source Development Model?*, 52 MGMT. SCI. 1116, 1124–26 (2006).

101. *Id.* at 10.

102. *Id.* at 8–10; Eric von Hippel, *Economics of Product Development by Users: The Impact of "Sticky" Local Information*, 44 MANAGEMENT SCIENCE 629, 632, 639 (1998).

103. *Id.*

104. *Id.* at 9–10.

105. Carliss Baldwin, Christoph Hienerth & Eric von Hippel, *How User Innovations Become Commercial Products: A Theoretical Investigation and Case Study*, 35 RES. POL'Y 1291, 1291–92 (2006).

106. *Id.* at 9–10.

manufacturing, exploiting complementary capabilities and resources to produce larger volumes of less specialized goods.[107]

The empirical studies referenced in this section document the growing volume and diversity of ways in which producers and users collaborate, as well as the opportunities for welfare gains from such cooperation.[108] Collaboration is not always easy, however. User communities offer valuable resources to producers, but they also pose risks to producers where they make their innovations freely available to others, since their open modes of innovation often conflict with the tightly controlled, proprietary intellectual property strategies of producers.[109] In addition, where users and producers seek to collaborate, they must navigate very different modes of knowledge production and diffusion and balance different—and sometimes conflicting—interests and motivations. In models of open collaborative user innovation, norms of trust and reciprocity function to induce and sustain sharing of innovations by user participants.[110] These nonmarket motivations and mechanisms have been explored within privately ordered communities that engage in innovation without the formal and direct use of intellectual property, although even there the presence of intellectual property impacts the behavior of participants.[111] As both collaboration across boundaries and competition across boundaries increase, it becomes impossible to isolate alternative mechanisms for producing and using knowledge.[112] Instead, firms and user communities must experiment to find sustainable producer–user ecosystems.[113]

Where producers and users are innovating together, it becomes important to consider how the patent law framework accommodates, or does not accommodate, these heterogeneous collaborations.[114] Producer–user ecosystems must find a balance between vertically integrated production and open distributed

---

107. *Id.* at 1291–99, 1306–07 (discussing how model pathways are common as user innovations are transformed to commercial products, test model against the history of the rodeo kayak industry).

108. Gambardella, *supra* note 98, at 13 (2016).

109. Hippel & Raasch, *supra* note 57, at 2, 5–6, 8, 18.

110. *See, e.g.*, Siobhan O'Mahony & Fabrizio Ferraro, *The Emergence of Governance in an Open Source Community*, 50 ACAD. MGMT. J. 1079, 1081 (2007).

111. *See, e.g.*, Strandburg, *supra* note 20, at 241–42; Vertinsky, *supra* note 26, at 1095.

112. Hippel, *supra* note 57, at 6, 14–15.

113. *See, e.g.*, Christoph Hienerth et al., *Synergies Among Producer Firms, Lead Users, and User Communities: The Case of the LEGO Producer-User Ecosystem*, 31 J. PRODUCT INNOVATION MGMT. 848, 849–51, 861 (2014) (examining alternative strategies by which firms involve users in product development, including lead user methods, firm-hosted user communities, and mass customization toolkits; describes pioneering design of producer-user ecosystems).

114. Baldwin & Hippel, *supra* note 53, at 1414.

innovation and between closed and producer centered processes and user centered processes.[115] In general, innovation policies have been focused on producer, rather than open, distributed and user-centered innovation, making it potentially harder to support the user-driven innovation within the ecosystem.[116]

Patents can create at least three areas of tension for producer–user collaborations.

A first area of tension arises from the focus of the patent system on identifying the inventor in ways that may be both over- and under- inclusive. Identifying a discrete inventor or group of co-inventors may be difficult in open, distributed systems of innovation where many different actors make incremental improvements and freely share their ideas in open forums.[117] With little documentation and a free flow of participants in and out of collective forums it may be impossible to identify who is, and who is not, a joint inventor for purposes of patenting.[118] In addition, patents will create a divergence between contributions and benefits in some cases, providing some types of intellectual production and some innovators with exclusive rights while leaving others without such rights.[119]

In addition to challenges in finding and isolating individual inventors and separating them from contributors of other types of knowledge and resources, the focus on the exclusive rights of the inventor can disadvantage the community of user-innovators in a cross-boundary collaboration. A second area of tension arises from the lack of protections for users in the patent law framework. Patent rules are geared towards defining and protecting the rights of the inventor over his or her invention, with little protection for the broader community that has shared their ideas and knowledge and served as the catalyst for user innovations.[120] Producers are more likely than users to seek patents, further exacerbating this problem.[121] This lack of attention to the rights of users is

---

115. *See, e.g.*, HIPPEL, *supra* note 54, at 2; Hienerth, *supra* note 113, at 848. (describing shifts in innovation systems).

116. *See, e.g.*, Hippel & Jong, *supra* note 16, at 5–6 (arguing that current innovation policy ignores that innovation is increasingly open, distributed and user-centered, relying instead on a logic of producer-centered innovation in policy formation).

117. *See* Lee, *supra* note 11, at 69.

118. See, e.g., Georg von Krogh et al., *Community, Joining, and Specialization in Open Source Software Innovation: A Case Study*, 32 RES. POL'Y 1217, 1221 (2003).

119. *See* N. Franke, P. Keinz, & K. Klausberge, *"Does This Sound Like a Fair Deal?" Antecedents and Consequences of Fairness Expectations in the Individual's Decision to Participate in Firm Innovation*, 24 ORG. SCI. 1495, 1502 (2013).

120. *See* Vertinsky, *supra* note 26, at 1095–97.

121. See Jason Schultz & Jennifer M. Urban, Protecting Open Innovation: The Defensive Patent License as a New Approach to Patent Threats, Transaction Costs, and

problematic for modes of innovation that are essentially driven by users and motivated by the desire to facilitate and encourage use.

A third and related problem in fostering sustainable collaboration between users and producers is the difficulty of jumping from a system in which ideas are shared and appropriability of knowledge is limited to a system that relies on appropriability. If inventions have not been patented, producers may lack the incentives needed to engage in further development. If, on the other hand, producers patent improvements and limit user access to the discoveries they have made, this can discourage users from disclosing their inventions in the first place and may dampen both their enthusiasm for and ability to make further incremental improvements. While user-communities may not need or value patent rights within their user-communities, once they begin interaction with producers, they risk the appropriation of their intellectual assets and the potential for producers to exclude them from improvements on their own innovations.[122] In addition, users who come up with discoveries that have value to the user-community may themselves see greater benefits and lower costs from engaging in patenting rather than sharing their ideas.[123] Once patents are introduced into the user community, this can result in the breakdown of the norms of trust, sharing, and reciprocity that govern many user–innovator communities. "In contrast to hierarchies or other forms of networks, exchange processes between members in user communities are not based on formal contracts but on 'relational contracts' in the form of trust, shared norms and values, as well as general reciprocity."[124] This mode of governance can be undermined by the incentives that patents create for defection from user communities and the problems of patent hold-up and extraction of value by producers through their patenting behavior.[125]

The resulting tensions between the incentives and rights that patents create and systems of collective production and sharing of discoveries by users can create high coordination costs, as users become reluctant to share their innovations and become wary of working with producers. Interestingly, and perhaps in response to

---

Tactical Disarmament, 26 HARV. J. L. & TECH. 1, 3 (2012).

122. *See, e.g.*, Franke et. al, *supra* note 119, at 1496 (2013).

123. *See* Vertinsky, *supra* note 26, at 1095–96.

124. *See* Hienerth, *supra* note 113, at 850 (internal citations omitted); *see also* Demil, B. & X. Lecocq, *Neither Market nor Hierarchy nor Network: The Emergence of Bazaar Governance*, 27 ORG. STUD. 10 1447–66.

125. See discussion of incentive problems that patents can create for cooperative systems in Vertinsky, *supra* note 26, at 1095–03 (discussing incentive problems that patents can create for cooperative systems).

this challenge of working with producers, some user communities have engaged in proprietary intellectual property strategies in the development of user brands.[126] In some cases, producers are finding it profitable to co-brand with user communities, and this form of co-branding has been shown to create comparatively high brand premiums.[127] Perhaps co-brands could operate as a means for producers to pre-commit by producers to rules that support user-communities by producer partners.

B. Collaboration Across the Public–Private Divide

Collaborative innovation between public and private stakeholders is increasingly encouraged as a way of multiplying the ideas, resources, and capabilities of government and its private partners.[128] Public–private collaboration is driven in part by government interest in pursuing economic competitiveness and in part by the desire of the private sector to share costs and risks.[129] There is an increase in public–private partnerships in areas of grand challenge, such as biotechnology and climate change, fueled by the desire to combine and channel public and private resources in a focused way towards strategically coordinated initiatives that address critical translational gaps in areas of public importance.[130] But despite the proliferation in public–private partnerships engaging in joint R&D, there is little guidance as to best practices

---

126. *See, e.g.*, Johann Fueller & Eric von Hippel, *Costless Creation of Strong Brands by User Communities: Implications for Producer Owned Brands*, MIT Working Paper (2008) (*available at* https://evhippel.files.wordpress.com/2013/08/johann-user-brands-oct-12-08_final.pdf [https://perma.cc/KY5E-Z2UK]) (showing that user communities can and do develop strong proprietary brands that compete with producer brands and generate brand premiums).

127. *Id.*

128. *See, e.g.*, JACOB TORFING, COLLABORATIVE INNOVATION IN THE PUBLIC SECTOR, 33–35 (2016) (examining nature, drivers and barriers to collaborative innovation involving the public sector and other partners); M. Reich, *Public-Private Partnerships for Public Health*, 6 NATURE MED. 617, 617–18 (2000) (describing different organizations which are promoting public-private collaborative innovation).

129. Adams, *supra* note 41, at 335–36 (public–private collaboration driven by "government interest in exploiting research for economic competitiveness").

130. *See, e.g.*, Magdalini Papadaki & Gigi Hirsch, *Curing Consortium Fatigue*, 5 SCI. TRANSLATIONAL MED. (2013) (arguing for the need for a science of collaboration to evaluate and inform multi-stakeholder collaboration environment in biomedical innovation); Reich, *supra* note 128, at 618 ("both public and private participants are being driven towards each other, with some amount of uneasiness, to accomplish core objectives. Yet we know little about the conditions when partnerships succeed."); Liza Vertinsky, *Patents, Partnerships, and the Pre-Competitive Collaboration Myth in Pharmaceutical Innovation*, 48 U.C. DAVIS L. REV. 1509, 1537–39 (2015) (examining tensions between patents and collaborative public-private R&D partnerships).

for such collaborations, and intellectual property can sometimes be a hindrance rather than a facilitator of such arrangements.[131]

Collaborations between public and private entities are particularly important in science-based industries such as semiconductors, electronics, computing, and biotechnology. A distinguishing feature of these industries is the close connections that form between private firms and public research institutes and universities.[132] In these sectors, the knowledge base that private firms rely upon is at least partly external to the firm, produced by publicly funded research institutes and universities. Both formal and informal relationships emerge between firms and the research institutions they are embedded in to facilitate knowledge flows, blurring the boundaries between these entities.[133] "Rather than categorizing the government-funded research institute and university as a separate 'supporting institution,' supporting the activities of the firm, some scholars have suggested that it makes more sense to see the firm and those government-funded research institutes and universities from which it derives part of its knowledge base as a hybrid institution."[134] As the boundaries blur, the need for patents as necessary mechanisms for knowledge transfer is much less than it is for arm's length collaboration. Instead, patents act largely to allocate control over and benefits from collaborative discoveries. Unfortunately, they may do so in ways that do not always properly balance public and private contributions or interests. Indeed, patents are likely to systematically over-reward the private sector participants, who tend to engage in later stage developments that are more readily patented. Conversely, they are likely to under-reward the public-sector participants, who are concentrated in upstream

---

131. *Id.*

132. *See, e.g.*, A. Kaufmann & F. Todtling, *Science-Industry Interaction in the Process of Innovation: The Importance of Boundary-Crossing Between Systems*, 30 RES. POL'Y 791, 902–03 (2001) (examining importance of science-industry interaction in innovation); NATIONAL SYSTEMS OF INNOVATION: TOWARD A THEORY OF INNOVATION AND INTERACTIVE LEARNING (B. Lundvall ed., 1992), 2 ("[A] system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge.").

133. *See, e.g.*, Martin Fransman, *Designing Dolly: Interactions Between Economics, Technology and Science and the Evolution of the Hybrid Institutions*, 30 RES. POL'Y 263, 264–65 (2001) (examining "institutional embeddedness" of the process of cloning that led to the cloned sheep Dolly; exploring the hybrid firm that has emerged in science-based industries, embedded in the institutions of government and universities; showing "importance of. . . hybrid institutions in facilitating the interactions between economic, technological, and scientific processes that" drive economic change).

134. *Id.* While traditional economic and legal analysis has treated firms as distinct from the institutions in which they are often embedded, "the boundaries that distinguish 'the firm' from 'the government funded research institute' or 'the university' are blurred from all but a legal point of view." *Id.* at 264.

areas of early stage research that is often either freely shared or licensed to the private sector on terms favorable to the private sector.[135]

The current patent law framework creates at least three types of challenges for sustainable and effective public–private collaborations. The first is the focus of the patent law framework on rewarding the producer–inventor through exclusive rights to the invention, a focus that leads to a public–private sharing of the costs but not the benefits from joint R&D projects.[136] The Bayh–Dole Act allows private entities that make inventions through the use of government funding to elect title to their inventions and license those inventions without accounting for profits to the government.[137] Where the government is the inventor, or a joint-inventor, the result is often a license from the government to the private sector participant, often at a royalty that does not adequately capture the public contributions to the invention even once the risk of private sector development is accounted for.[138] A recent example is the proposed licensing of a Zika vaccine from the public to the private sector on terms highly favorable to the industry partner.[139]

A second and related problem is the lack of attention to the public interest in access, which in many public private research collaborations takes the form of broad public interest in diffusion and access to knowledge and discoveries. The framework for governing public–private partnerships is based on a model of technology transfer from the public to the private partner, with the underlying premise that the best way to serve the public interest is to ensure that the technology is commercialized by the private partner.[140] This limited approach towards what is increasingly a situation of joint R&D rather than a situation of transferring technology for private R&D results in a failure to

---

135. *See* H. Stevens et al., *Intellectual Property Policies in Early-Phase Research in Public-Private Partnerships*, 34 NATURE BIOTECHNOLOGY 504, 504–06 (2016) (examining patent arrangements in survey of public-private partnerships in early phase R&D).

136. *See* MAZZUCATO, *supra* note 50, at 145–46 (making the case that government takes on risk and engages in entrepreneurial activity but increasingly does not share in the benefits of this investment).

137. Bayh–Dole Act, Pub. L. 96-517, 94 Stat. 3019 (1980).

138. See Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 VA. L. REV. 1663, 1666–67 (1996).

139. Kim Treanor, *Groups Seek Assurance of Affordable Zika Vaccine from US Army Exclusive License*, INTELLECTUAL PROPERTY WATCH (January 19, 2017), https://www.ip-watch.org/2017/01/19/groups-seek-assurance-affordable-zika-vaccine-us-army-exclusive-licence/ [https://perma.cc/43JY-SKGG].

140. Eisenberg, *supra* note 138, at 1668.

ensure that rents are shared and that innovation plans adequately incorporate and reflect broad public interests. Notwithstanding the benefits of the existing technology transfer system as a way of ensuring that early stage ideas reach the market, problems emerge where the process does not adequately balance public and private interests—particularly in the case of fundamental technologies. Recent debates about how public access to the important CRISPR technology will be handled illustrate the competing interests at play in areas that are the result of public private collaboration, as well as the role of patents in fueling tensions between public and private interests.[141]

Third, patents can exacerbate coordination problems where different communities use different incentive structures and have divergent goals regarding knowledge production and sharing. Participants with very different incentive structures and different norms regarding the production and use of knowledge must come together and agree upon shared rules for intellectual production and use. They must then establish hybrid mechanisms for ensuring adherence to the agreed-upon rules. Patents can exacerbate the costs of agreeing upon governance rules in the first place and can create incentive problems for participants once they are collaborating.[142] The need to address issues of patenting and patent ownership prior to a collaboration can increase transaction costs and decrease the speed and likelihood of reaching agreement. The failure to address these issues in advance can result in an unfair distribution of benefits ex post as well as a potentially suboptimal use of resulting discoveries. Patents can also undermine the trust that is needed between diverse participants by creating opportunities for the private partner to appropriate the benefits of public knowledge contributions through patenting.

A repeated theme in any discussion of collaborations is the importance of establishing and maintaining trust among the participants.[143] Differential ability and incentives to appropriate and limit access to knowledge through the use of patents can undermine this trust. While patents can and do facilitate some kinds of public–private partnerships in some ways, they also create problems that stem in part from the lack of room within the

---

141. *See, e.g.*, Jacob Sherkow, *CRISPR: Pursuit of Profit Poisons Collaboration*, 532 NATURE 172, 172–73 (2016) (examining how patents may create incentives that jeopardize scientific collaboration where the breakthroughs have tremendous commercial potential).

142. See discussion of incentive problems that patents can create for cooperative systems in Vertinsky, *supra* note 26, at 1095–103.

143. *See* Virginia Gewin, *Collaborations: Recipe for a Team*, 523 NATURE 245, 245 (2015) (importance of trust in sustaining scientific collaboration); Vertinsky, *supra* note 26, at 1070; *see also* BENNETT, *supra* note 22 at 21.

patent law framework for appropriate balancing of public and private interests and the exclusion of valuable but often unpatentable background knowledge (often contributed by the public partner) from protection. While patents are often important or even necessary in the structuring of public private collaborations, patents also create costs that can limit the benefits of public–private collaboration or deter it altogether if not carefully managed.

C. Human–Machine Collaboration

> "[I]n not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today."
>
> - J.C.R. Licklider[144]

One of the most potentially transformative areas of boundary-spanning collaboration is that of collaboration between humans and intelligent machines. Alan Turing is often credited as being one of the first to explore the idea and implications of machines that have the ability to "think" like humans, and his work along with others in the field in the 1930s and 1940s set in motion what has now become widely known as "artificial intelligence."[145] Since that time, the artificial intelligence landscape has seen many changes, with new and wide ranging applications of artificial intelligence (AI) and its derivative thinking machines and the emergence of broader cognitive technologies.[146] Machine capabilities now encompass computer vision, speech recognition, and different types of machine learning.[147] Rather than simply tools to be used by humans in their cognitive pursuits, machines are increasingly participating as

---

144. Quoted in Arati Prabhakar, *The Merging of Humans and Machines is Happening Now*, WIRED (Jan. 27, 2017), http://www.wired.co.uk/article/darpa-arati-prabhakar-humans-machines [https://perma.cc/XZL9-C98K].

145. *See, e.g.*, O. Shani, *From Science Fiction to Reality: The Evolution of Artificial Intelligence*, WIRED (Jan. 27, 2017), https://www.wired.com/insights/2015/01/the-evolution-of-artificial-intelligence/ [https://perma.cc/V6T2-VCQ4].

146. *Id*.

147. *See, e.g.*, Richard Adhikari, *Microsoft AI Beats Humans at Speech Recognition*, TECHNEWSWORLD (October 20, 2016 11:40 AM), http://www.technewsworld.com/story/84013.html [https://perma.cc/X2D9-8PKK]; Helen Knight, *Putting the 'Art' in Artificial Intelligence*, MIT NEWS (December 12, 2011), http://news.mit.edu/2011/profile-torralba-1212 [https://perma.cc/XKQ7-W9WB]; Bernard Marr, *What Is the Difference Between Artificial Intelligence and Machine Learning?*, FORBES TECH (December 6, 2016 2:24 AM), https://www.forbes.com/sites/bernardmarr/2016/12/06/what-is-the-difference-between-artificial-intelligence-and-machine-learning/#274cfd832742 [https://perma.cc/BML9-SSUL].

collaborators with humans.[148] The chess world provides a great example of this shift in both role and thinking. In 1997, the computer—IBM's Deep Blue—was pitted against the world chess champion Garry Kasparov and won.[149] In 1998, Kasparov played the first public game of human–computer collaborative chess against a top-rated human competitor, each of them using a computer to assist them.[150] Recent innovations in collaboration include human–machine collaboration in drug discovery[151] and combining human and machine intelligence in crowdsourcing models, with the computer serving as the organizer for distributed innovation.[152]

Human–machine collaboration can be understood as "a model in which humans co-work with artificial intelligence . . . and other machines," harnessing the complementary strengths of each.[153] In some cases, machines directly augment human capabilities through machine implants in the human body.[154] While machines can augment human cognitive capabilities, they can also perform cognitive tasks on their own. They can and are generating patentable subject matter in ways that make them, rather than their human counterparts, the sources of the invention.[155] An early example is the Creativity Machine, invented and patented by Dr.

---

148. *See Crowd-Augmented Cognition: Team Develops Tools that Combine Human and Machine Intelligence to Accelerate Learning*, PHYS.ORG (May 11, 2016), https://phys.org/news/2016-05-crowd-augmented-cognition-team-tools-combine.html [https://perma.cc/68HN-X7QQ].

149. *See, e.g.*, *The Rise of the Centaurs*, at http://smarterthanyouthink.net/excerpt/ [https://perma.cc/LK3K-MBSD] (describing evolution of the computer-human collaborative chess game).

150. *Id*.

151. *See* Prabhakar, *supra* note 144.

152. *See Crowd Augmented Cognition: Team Develops Tools that Combine Human and Machine Intelligence to Accelerate Learning*, PHYS.ORG (May 2016), https://phys.org/news/2016-05-crowd-augmented-cognition-team-tools-combine.html [https://perma.cc/68HN-X7QQ].

153. Margaret Rouse, *Definition: Machine-Human Collaboration*, WHATIS.COM http://whatis.techtarget.com/definition/machine-human-collaboration [https://perma.cc/M66S-ZFX8]; Terence Brake, *Human-Machine Collaboration: The Machine as Talent*, TMA WORLD (May 5, 2015), http://www.tmaworld.com/our-thinking/human-machine-collaboration-machine-talent [https://perma.cc/TB5J-N4UX] (suggesting that as cognitive technologies continue to develop, machines are now being thought of as talent, not just people).

154. *See* Liat Clark, *Elon Musk Reveals More about His Plan to Merge Man and Machine with Neuralink*, WIRED (April 2017), http://www.wired.co.uk/article/elon-musk-neuralink [https://perma.cc/6CBM-UQ7D].

155. *See* Liza Vertinsky & Todd M. Rice, *Thinking About Thinking Machines: Implications of Machine Inventors for Patent Law*, 8 B.U. J. SCI. & TEC. L. 574, 585 (2002); Ryan Abbott, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law*, 57 B.C. L. REV. 1079, 1079–82 (2016).

Thaler—a machine credited with making patentable inventions that Thaler filed in his own name.[156]

Human–machine collaborations raise some of the most complex and difficult issues for the patent law framework, challenging all aspects of the traditional paradigm of invention and inventor.[157] Here, I focus on three of the most immediate doctrinal questions that arise where humans engage in collaborative innovation with machines.[158]

The most obvious area of challenge for human–machine collaborative invention is the question of inventorship.[159] Invention is regarded as something that occurs through the intellect and insight of the human inventor rather than as an interactive process between human and machine or as something that could be done solely by a machine.[160] Patent law has a hard-enough time even moving from one to two inventors, let alone contemplation of a machine inventor or co-inventor. While there is no provision in patent law that explicitly requires a human inventor, there are many provisions that presume or implicitly require one or more human inventors, suggesting that only people can be considered inventors under current patent law.[161] Patent law seems to presume one or more human inventors.

With this as the starting point, patent policymakers have yet to provide any policy guidance on how to handle machine co-inventors, machine inventors, or the patenting of the computational processes for making inventions.[162] By not

---

156. *See id.* at 1083–86 (2016) (discussing Creativity Machine and the patenting of inventions produced by the machine). *See also* ROBERT PLOTKIN, THE GENIE IN THE MACHINE: HOW COMPUTER-AUTOMATED INVENTING IS REVOLUTIONIZING LAW & BUSINESS 1–2 (2009) (referring to era of computer-automated invention as the Artificial Invention Age and suggesting role of human inventors will be to formulate high level descriptions of problems to be solved).

157. *See, e.g.*, Liza Vertinsky, *Thinking Machines and Patent Law*, *in* RESEARCH HANDBOOK OF ARTIFICIAL INTELLIGENCE (Forthcoming 2018), *available at* https://ssrn.com/abstract=3036030; Vertinsky & Rice, *supra* note 155, at 585–87; Abbott, *supra* note 155, at 1079–81; Shlomit Yanisky-Ravid & Xiaoqiong (Jackie) Liu, *When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law*, CARDOZO L. REV. (forthcoming 2017).

158. For a broader discussion, *see generally* Vertinsky, *supra* note 157.

159. *See e.g.*, Abbott, *supra* note 155, at 1079–81 (2016); Yanisky-Ravid, *infra* note 157.

160. *See, e.g.*, Burroughs Wellcome v. Barr Labs., 40 F.3d 1223, 1226–27 (Fed. Cir. 1994).

161. *See* U.S. CONST. art. I, § 8, cl. 8 ("The Congress shall have Power To . . . promote the Progress of the Science and useful Arts, by securing for limited Times to the Authors and Inventors the exclusive Right to their respective Writings and Discoveries . . ."); *see also* 35 U.S.C. § 100(f) (2012) ("The term "inventor" means the individual or, if a joint invention, the individuals collectively who invented or discovered the subject matter of the invention"); Inventions Patentable, 35 U.S.C. § 101 ("Whoever invents or discovers . . .").

162. *See* Abbott, *supra* note 155, at 1080 (discussing lack of guidance from patent law

confronting the growing practices of machine–human collaboration and machine-generated inventions, patent law is allowing (or even forcing) human collaborators to claim the benefits of inventions that they either jointly make with their machine counter-parts or derive from their machine collaborators if they want the invention to receive a patent. It is also allowing the patenting of the collaborators themselves to the extent that the cognitive capabilities of machines can be patented.

A second question is how, if at all, the determination of what is patentable should change in a world where machine–human collaboration is increasingly the norm rather than the exception. Among other requirements of patentability, an invention must satisfy the standards of non-obviousness and it must be adequately disclosed.[163] The use of current non-obviousness doctrine to guide determinations of patentability is based on whether the discovery would have been obvious to a person having ordinary skill in the art.[164] This approach relies upon distinctions between the knowledge and capabilities of people of ordinary skill in the art and the mental act of the inventor(s), distinctions which may be increasingly difficult to make if we expand the comparison to include what people with machine-enhanced skills would find obvious or at least "obvious to try."[165] Expanding the obviousness analysis to allow for machine-augmented human capabilities would create a heightened standard for patentability with widespread implications for all kinds of areas, not just the inventions arising from machine–human collaborations. But a failure to adjust the standard of obviousness to reflect access to artificial intelligence may result in an obviousness standard that is too low, resulting in too many patentable inventions. In addition to obviousness, the pervasive role of machines in the invention process may impact current tests for enablement under patent law.[166] A person working with a machine may be able to make and use an invention based on a very limited patent disclosure, meaning that even limited patent disclosures could enable a broader range of inventions. Machine-based enablement might

---

on how to handle machine-created inventions).

163. *See* Patentable Subject Matter, 35 U.S.C. § 101; Conditions for Patentability, Novelty 35 U.S.C. § 102; Conditions for Patentability, Non-Obvious Subject Matter, 35 U.S.C. § 103; Specifications, 35 U.S.C. § 112.

164. *See, e.g.*, Vertinsky & Rice, *supra* note 155, at 594–95.

165. *See e.g.*, See MPEP § 2143, Examples of Basic Requirements of a Prima Facie Case of Obviousness (8^{th} ed. Rev. 7, Sept. 2008) (rationales that may support a decision of obviousness include "obvious to try" or "choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success.").

166. *See* 35 U.S.C. § 112. *See also* MPEP § 2164, The Enablement Requirement (8^{th} ed. Rev. 7, Sept. 2008).

thus allow for an expanded patent scope for any particular patent disclosure.[167]

A third area of tension between the patent law framework and machine–human collaboration arises from the focus of the patent system on the exclusive rights of the (human) inventor. Failing to consider the change in the inventive process once human–machine collaboration occurs results in neglect of important questions about the distribution of incentives and rewards from the results of collaborative human–machine production. What is the best way to measure and reward the machine producer's contributions, contributions to the data that is used by the machine, and the contributions made by the person working with or utilizing the machine to solve a particular problem? Rather than ignore the question, patent policymakers need to think explicitly about how we should allocate rewards across the different contributors to machine invention, including the inventors of the cognitive technologies and the parties involved in the application of the cognitive technologies to a particular problem.[168] Decisions made about these distributional questions could impact patenting behavior quite significantly. While some of these issues could be handled in advance through contracts,[169] patent law provides important default starting positions for such negotiations and fills in where contracts are missing or contracting breaks down.

As the three collaboration paradigms discussed in this Part III illustrate, the process of innovation is changing in ways that challenge the existing model of inventor and invention for which patent law is designed. While a full analysis of where and how patent law should respond to changing modes of collaborative innovation is beyond the scope of this Article, I suggest that we should begin with the primary way in which patent law currently handles (or fails to handle) collaborative invention—the joint inventorship doctrine.

IV. The Uneasy Fit of Joint Inventorship Doctrine

Collaborative discovery is handled by the patent law framework primarily through identifying and treating multiple inventors as much as possible like a single inventor through the use of the joint inventorship doctrine.[170] As collaborations have

---

167. *See* Vertinsky, *supra* note 157.

168. *See* Yanisky-Ravid & Liu, *supra* note 157, at 51–54.

169. *See* Paul J. Heald, *A Transaction Costs Theory of Patent Law*, 66 OHIO ST. L.J. 473, 479 (2005).

170. W. Fritz Fasse, *The Muddy Metaphysics of Joint Inventorship: Cleaning Up after the 1984 Amendments to 35 U.S.C. § 116*, 5 HARV. J. L. & TECH. 153, 160–61 (1992)

grown, so too has the use of this doctrine, with a growing proportion of issued patents including more than one inventor. In 1970 roughly 40% of patents included more than one inventor, by 2000 approximately half of all patents listed more than one inventor.[171] In 2010 roughly 65% of patents issued had more than one inventor, with 40% of issued patents in 2010 having three or more inventors.[172] While joint inventorship is increasingly common, legal determination of who is a joint inventor remains difficult and often uncertain.[173] In this Part, I examine some of the limitations of the joint inventorship doctrine as the primary mechanism for handling the discoveries emerging from boundary-spanning collaborations such as those discussed in Part III.

A. *Traditional Paradigm: The Genius of the Lone (Co)-Inventor(s)*

The disconnect between current joint inventorship doctrine and at least some kinds of collaborative discovery arises from trying to fit a variety of different discovery processes and participants into a single inventor-centric model of invention. Patent law is intended to be agnostic as to the types of inventors and modes of invention, with limited exceptions such as differential fees for small businesses and individual inventors,[174] special rules concerning government owned and government funded inventions,[175] and modest efforts to address prior art issues

---

(explaining American patent law's "focus on joint conception makes the inquiry difficult in practice and impossible in theory" as it requires "single idea or thought" to "arise jointly and simultaneously in two [or more] minds.").

171. *See* John R. Allison & Mark A. Lemley, *Who's Patenting What? An Empirical Exploration of Patent Prosecution*, 53 VAND. L. REV. 2099, 2117 (2000).

172. *See* Crouch, *supra* note 62 (patents issued during past six months have an average of 2.7 inventors per patent, 68% have multiple inventors, 13% have five or more inventors); Dennis Crouch, *The Changing Nature Inventing: Collaborative Invention*, PATENTLY-O (July 9, 2009) (average number of inventors per issued patent rose from 1.6 in the 1970s to 2.5 in 2000); Bradly Krul, *The "Four C's" of Joint Inventorship: A Practical Framework for Determining Joint Inventorship*, 21 J. INTELL. PROP. L. 73, 82 (2013).

173. *See, e.g.*, Aaron Fellmeth, *Conception and Misconception in Joint Inventorship*, 2 NYU J. INTELL. PROP. & ENT. L. 73, 74 (2012) ("Among the mysteries emanating from uncertainty about what kinds of technologies qualify as a patentable invention, identifying the proper inventors has developed into one of the most intractable.").

174. *See* Micro Entity Defined, 35 U.S.C. § 123(a) (2012); Fees for Small Entities, 35 U.S.C. 41(h). These provisions are designed to make filing patent applications and maintaining patents less financially burdensome for individual inventors and small businesses.

175. *See* Patent Rights in Inventions Made with Federal Assistance, 35 U.S.C. Ch. 18 (2012) (dealing with special rules that apply both to federally owned inventions and to inventions that are made with federal funding).

that arise in research collaborations.[176] The statutory framework does not overtly distinguish between individualized and collaborative modes of invention except through recognizing joint inventorship,[177] with only limited provisions to address prior art,[178] prior user rights arising from independent invention,[179] and derivation issues[180] that may arise with particular frequency when parties work in a collaborative environment. While the statutory framework for patent law is theoretically agnostic as to how the invention is made or who it is made by, in practice it is neither agnostic in its conceptual underpinnings nor its application.[181] Rather, patent law presumes and is designed to fit an underlying paradigm of market based, producer driven invention with the individual inventor at its center.[182]

Abraham Lincoln, one of the early proponents of the patent system, is famously quoted for his justification of patents as having secured "to the inventor for a limited time exclusive use of his inventions; and thereby added the fuel of interest to the fire of genius in the discovery and production of new and useful things."[183] While patent law has changed considerably in many

---

176. *See* The Cooperative Research and Technology Enhancement (CREATE) Act, Pub L. 108-453 (2004). The CREATE Act allows certain joint owners of patent applications or patents to be treated as a common owner for purposes of excluding certain specified kinds of prior art provided they are parties to a specified form of joint research agreement. The CREATE Act originally amended 35 U.S.C. § 103(c) but now takes the form of 35 U.S.C. § 102(c) Common Ownership Under Joint Research Agreement, which provides that "subject matter disclosed and a claimed invention shall be deemed to have been owned by the same person or subject to an obligation of assignment to the same person in applying the provisions of subsection (b)(2)(C)" under specified conditions.

177. *See* Joint Inventors, 35 U.S.C. § 116 (2012).

178. *See* The Cooperative Research and Technology Enhancement (CREATE) Act of 2004, 35 U.S.C. § 102(c) (2012).

179. *See* 35 U.S.C. § 273, (2012) (providing post-AIA certain rights to prior users of an invention).

180. 35 U.S.C. § 135 (2012) (addressing derivation proceedings, situations in which an earlier patent application is alleged to have derived the invention from a later patent application without authority).

181. *See* Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1696 (arguing that while patent law is in theory industry neutral, in practice it is applied differently in different industry contexts). Note that this approach to invention without regard to the process by which the invention is made can be contrasted with antitrust law and policy, which has been tailored to differences in the ways that patents impact and are used in collaborative contexts. *See* DEP'T OF JUSTICE AND FED. TRADE COMM'N, ANTITRUST GUIDELINES FOR THE LICENSING OF INTELLECTUAL PROPERTY 3 (2017).

182. *See* Lee, *supra* note 11, at 4 ("highlights and challenges the narrow, particularized conception of innovation embedded in patent law . . . [which is] individualistic, discrete, noel, and objectively reproducible.").

183. *See* Gene Quinn, *Celebrating Presidents Who Advocated for the US Patent System*, IPWATCHDOG (Feb. 18, 2013), http://www.ipwatchdog.com/2013/02/18/celebrating-presidents-who-advocated-for-the-u-s-patent-system/id=34896/ [https://perma.cc/6Y4D-DRCG]; TODAYINSCI, https://todayinsci.com/L/Lincoln_Abraham/LincolnAbraham-Quotations.htm

respects since the first U.S. patent act, the Patent Act of 1790,[184] it has retained an attachment to the idea of the lone genius who, if properly incentivized, will apply his or her skill and intellect to solve problems and make discoveries that have evaded existing experts in the field. Invention is viewed as the mental act of the inventor, involving the conception of the subject matter of the invention in the mind of the inventor.[185]

The modern statutory framework for patent law continues to define invention as a mental act occurring in the mind of the inventor, with patents serving as mechanisms for rewarding the inventors who disclose their inventions to the public.[186] The touchstone of inventorship is conception of the invention,[187] where conception is viewed as "[f]ormation in the mind of the inventor of a definite and permanent idea of the complete and operative invention."[188] The conception is complete "only when the idea is so clearly defined in the inventor's mind that only ordinary skill would be necessary to reduce the invention to practice, without extensive research or experimentation."[189]

This approach to invention as the product of the mind and genius of the inventor reinforces the primacy of individual human inventors in patent law.[190] The U.S. Constitution and the Patent Act focus on "inventors" as the only people who can obtain patents on their inventions.[191] The test of conception is "whether the

[https://perma.cc/KYS2-9UHF].

184. *See* Vertinsky & Rice, *supra* note 155, at 584.

185. *See* Fellmeth, *supra* note 173, at 83 (2012).

186. For an early summary of this traditional theory of patents, see FRITZ MACHLUP, AN ECONOMIC REVIEW OF THE PATENT SYSTEM 33, STUDY OF THE SUBCOMMITTEE ON PATENTS, TRADEMARKS, AND COPYRIGHTS, 85th Cong., 2d Session (Comm. Print 1958); *see also* R. Mazzoleni & R. Nelson, *The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate*, 27 RES. POL'Y 273, 274–75 (1999) (advancing reward theory of patents pursuant to which patents preserve incentives to make and commercialize inventions).

187. *See* Burroughs Wellcome Co. v. Barr Labs., Inc., 40 F.3d 1223, 1227–28 (Fed. Cir. 1994) ("Conception is the touchstone of inventorship, the completion of the mental part of invention.").

188. Mergenthaler v. Scudder, 11 App. D.C. 264, 276 (D.C. Cir.1897) (quoted in *Burroughs Wellcome*, 40 F.3d 1228 and in Hybritech v. Monoclonal Antibodies, Inc., 802 F.2d 1367, 1376 (Fed. Cir. 1986)).

189. *Burroughs Wellcome*, 40 F.3d at 1228.

190. Decisions spanning the decades focus on the formation of the invention in the mind of the inventor(s). "Formation in the mind of the inventor of a definite and permanent idea of the complete and operative invention." *Mergenthaler,* 11 App. D.C. at 276; *Hybritech*, 802 F.2d at 1376. "Conception is complete only when the idea is so clearly defined in the inventor's mind that only ordinary skill would be necessary to reduce the invention to practice, without extensive research or experimentation." Sewall v. Walters, 21 F.3d 411, 415 (Fed. Cir. 1994).

191. *See* U.S. CONST. art. I, § 8, cl. 8 (Congress shall have power "To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors

inventor had an idea that was definite and permanent enough that one skilled in the art could understand the invention."[192] Once inventorship has been determined, the individual inventors are the original owners of their inventions. In general, it is the inventor or inventors who apply for patents, and the inventor or each joint inventor must be identified in the patent application and issued patent.[193] Once an inventor obtains a patent, it has "the attributes of personal property."[194]

Theories justifying patent law have remained largely tied to this traditional inventor-centric paradigm. The dominant reward theory of patents as mechanisms for inducing inventors to make and disclose inventions has proven to be enduring and hard to displace, although scholars have continued to suggest alternative functions for and justifications of patents.[195] The prospect theory of patents provides one of the earliest and most enduring alternative justifications for the patent system, but rather than depart from the primacy of the inventor it simply emphasizes a different role for giving the inventor broad patent rights, one based on facilitating downstream investments in the development of derivative inventions.[196] As attention has shifted to more collaborative models of innovation, themes of coordination and cooperation enabled by the greater ability to disclose and transfer information have gained traction in patent scholarship.[197] In an expansion of the prospect theory to encompass the follow-on process of innovation, patents have been seen as supporting the coordination of investments needed to commercialize an

---

the exclusive right to their respective writings and discoveries."); *see also* 35 U.S.C. § 111(a)(1) (2006) ("An application for patent shall be made, or authorized to be made, by the inventor, except as otherwise provided in this title . . . .).

192. *Burroughs Wellcome*, 40 F.3d at 1228.

193. The Leahy-Smith America Invents Act has revised rules regarding applications for patents to shift the focus from inventors to owners, but the individualistic nature of the process remains. *See* Dennis Crouch, *AIA Shifts Focus from Inventors to Patent Owners*, PATENTLYO (Aug. 14, 2012), https://patentlyo.com/patent/2012/08/aia-shifts-usptos-focus-from-inventors-to-patent-owners.html [https://perma.cc/6KE6-K6NC].

194. Ownership; Assignment, 35 U.S.C § 261 (2012).

195. *See, e.g.*, Richard Nelson & Roberto Mazzoleni, *Economic Theories About the Costs and Benefits of Patents*, 32 J. ECON. ISSUES 1031, 1034, 1038, 1040, 1042 (1998) (identifying four broad theories about principal purposes of patents: (1) invention-inducement theory, (2) disclosure theory, (3) development and commercialization theory—patents induce investment in commercialization, and (4) prospect development theory—patents enable orderly exploitation of broad prospects for derivative inventions.). *See generally* ROBERT P. MERGES, JUSTIFYING INTELLECTUAL PROPERTY (2011) (examining justifications for IP, provides role for mid-level principles that can be used to guide application of IP).

196. *See* Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. ECON. 265 (1977) (arguing that patent rights enable the exploration and management of follow-up investments on improvements to an early technology).

197. See summary of these different functions in Yelderman, *supra* note 19, at 1565–66.

invention.[198] Patent scholars have also suggested that patents reduce transaction costs in the exchange of information, thus increasing disclosure and facilitating technology transfer.[199] Patents have been seen as signals of firm value to attract finance.[200] Some scholars have even focused specifically on the role of patents in supporting collaboration, including the role of patents in allocating rights and rents within joint ventures,[201] the role of patents in solving problems of team production by acting as affirmative asset partitions,[202] the role of patents as sources of organization,[203] and the role and limits of patents in transferring know-how and tacit knowledge across organizational boundaries.[204]

Despite the growth in more collaboration focused accounts of patents, however, the alternative functions ascribed to patents and justifications provided for them for the most part continue to presume a model of individual-producer driven invention. Although patent scholars have incorporated a broader view of the process of innovation into patent theories, most of the resulting patent theories and policies still share a common neglect of the

---

198. *See* F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697, 707 (2001); *see also* F. Scott Kieff, *Thinking About IP and Collaboration at the Patent-Antitrust Interface*, IPWATCHDOG (April 9, 2017), http://www.ipwatchdog.com/2017/04/09/ip-patent-antitrust-interface/id=81893/ [https://perma.cc/BQ93-KUW6] (summarizing the commercialization approach to patents in which patents are seen as tools for facilitating interaction among private parties, supporting collaboration by allowing private parties to interact over and around patent rights).

199. *See, e.g.*, Nancy Gallini & Ralph Winter, *Licensing in the Theory of Innovation*, 16 RAND J. ECON. 237, 249 (1985); Heald, *supra* note 169, at 478; Penin, *supra* note 19, at 654; Robert Merges, *A Transactional View of Property Rights*, 20 BERKELEY TECH. L.J. 1477, 1519 (2005).

200. *See, e.g.*, Clarissa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 657–59 (2002); Stuart Graham et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1305–08 (2009) (shows importance of patents in securing funding).

201. *See* Ashish Arora & Robert Merges, *Specialized Supply Firms, Property Rights, and Firm Boundaries*, 13 INDUS. & CORP. CHANGE 451, 468 (2004).

202. *See* Heald, *supra* note 169, at 507 (2005).

203. *See, e.g.*, Jonathan Barnett, *Intellectual Property as a Law of Organization*, 84 S. CAL. L. REV. 785, 856–57 (2011) (examining relationship between IP, firm organization and market structure in this and a series of related papers); Jonathan Barnett, *Dynamic Analysis of Intellectual Property: Theory, Evidence and Policy* 14–16 (2013) (*available at* http://law.bepress.com/usclwps-lewps/163/ [https://perma.cc/R625-WZW8]) (providing model in which both the state and the private sector supply IP, considers private action to changes in state IP policy, focuses on manner in which changes in public IP influence market's selection of organizational forms).

204. *See, e.g.*, Peter Lee, *Transcending the Tacit Dimension: Patents, Relationships, and Organizational Integration in Technology Transfer*, 100 CAL. L. REV. 1503, 1572 (2012) (exploring limits of patents in transferring tacit knowledge and organizational responses).

social context of these collaborative processes of innovation.[205] This can be contrasted with the detailed contextual account of intellectual production taking place without the use of intellectual property in the burgeoning "innovation without IP" literature, including detailed studies of French cuisine,[206] comedy,[207] fashion,[208] and a variety of different modes of user innovation.[209]

The result of this attachment to an abstract inventor-centric model of invention is a patent law framework and supporting theories that do not work well in a number of collaboration contexts.[210] They work best where private actors seeking to maximize their own economic interests interact over and around patent rights in the market place, with patents as "tools for facilitating coordination among these diverse private actors, in furtherance of their own private interests in commercializing the creation or invention."[211] This mode of collaboration fits relatively neatly into the producer–inventor paradigm. The existing patent law framework is more likely to cause problems where innovation emerges from the flow of knowledge and ideas across organizational, disciplinary, and geographic boundaries as networks of actors with diverse motivations and interests work together collaboratively and often informally, without contracts or employment relationships with each other.

205. *But see e.g.*, Michael Mattioli, *Communities of Innovation*, 106 NW. U. L. REV. 103 (2015); Pedraza-Fariña, *supra* note 4; Robert P. Merges, *Intellectual Property Rights and the New Institutional Economics*, 53 VAND. L. REV. 1857 (2000).

206. *See* Emmanuelle Fauchart & Eric von Hippel, *Norms-Based Intellectual Property Systems: The Case of French Chefs*, 19 ORG. SCI. 187, 195–96 (2008) (studying the norms-based IP system that governs copying and reuse of recipes among high-end French chefs).

207. Dotan Oliar & Christopher Sprigman, *There's No Free Laugh (Anymore): The Emergence of Intellectual Property Norms and the Transformation of Stand-Up Comedy*, 94 VA. L. REV. 1787, 1865–66 (2008).

208. Kal Raustiala & Christopher Sprigman, *The Piracy Paradox: Innovation and Intellectual Property in Fashion Design*, 92 VA. L. REV. 1687, 1774–75 (2006).

209. *See generally* HIPPEL, *supra* note 54 (exploring role of users, interacting socially and without prices or property, in processes of innovation and the need for co-existence of producer and user innovation); Katherine J. Strandburg, *User Innovator Community Norms at the Boundary Between Academic and Industrial Research*, 77 FORD. L. REV. 2237 (2009); Katherine Strandburg, *Users as Innovators: Implications for Patent Doctrine*, 79 U. COLO. L. REV. 467 (2008).

210. *See, e.g.*, Benkler, *supra* note 7, at 2 (distinguishing between role of patents where innovation is a process of discrete contributions by individual actors, where patents may work well, and situations where "innovation is primarily an emergent property of knowledge flows, sharing, and collective learning in communities of practice and knowledge networks" where patents are likely to be counterproductive); Lemley, *supra* note 5, at 760.

211. *See* Kieff, *supra* note 198.

B. Doctrine of Joint Inventorship

> "The exact parameters of what constitutes joint inventorship are quite difficult to define. It is one of the muddiest concepts in the muddy metaphysics of the patent law."[212]

Given the inventor-centric nature of the patent law framework, along with the theories that explain and justify it, it is no surprise that even moving from one to two inventors creates challenges for patent law doctrine. Although it has a long history of precedent, patent inventorship continues to be one of the more complex areas of patent law, and considerable uncertainty remains over what makes a person a joint inventor.[213] Indeed, the concept of joint inventorship has been referred to by courts and patent scholars as "one of the muddiest concepts in the metaphysics of patent law."[214]

Prior to a 1984 amendment, the Patent Act recognized joint inventorship but did not define it.[215] Instead, the Patent Act's defining provisions were entirely procedural, simply stating that "[w]hen an invention is made by two or more persons jointly, they shall apply for patent jointly" and then specifying requirements for signing the application and making a required oath, along with procedural measures where a joint inventor was either not included, wrongly listed, or refused to join in the application.[216] Courts during this time imposed a minimum threshold of contribution, requiring joint inventors to contribute in an original manner to the conception of the invention.[217] Once found to be joint inventors, the Patent Act provided each co-inventor with equal

212. Mueller Brass Co. v Reading Indus. Inc., 352 F. Supp. 1357, 1372 (E.D. Pa. 1972), *aff'd*, 487 F.2d 1395 (3d Cir. 1973).

213. *See* Fellmeth, *supra* note 173, at 95 (stating that the "process of identifying whether a collaborator qualifies as a joint inventor was until very recently crude and uncertain, and even today the law remains underdeveloped," and arguing that fixating on patent claims distorts inventorship determinations, argues for a disaggregation of patent claims from invention to restore integrity to concept of inventorship); Eric Ross Cohen, *Clear as Mud: An Empirical Analysis of the Developing Law of Joint Inventorship in the Federal Circuit*, 28 BERKELEY TECH. L.J. 383, 411 (2013) (analyzes joint inventorship cases that have come before the Federal Circuit since its inception).

214. *See Mueller Brass Co.*, 352 F. Supp. at 1372 (referring to joint inventorship as "one of the muddiest concepts in the muddy metaphysics of the patent law."); *see also* G. Sirilla, *How the Federal Circuit Clarified the "Muddy Concept" of Joint Inventorship*, 91 J. PAT. & TRADEMARK OFF. SOC. 509, 514–16 (2009) (arguing the Federal Circuit has helped to clarify joint inventorship in situation where one or more inventors has an initial idea, not yet reduced to practice, and enlist the aid of others to perfect the idea and/or reduce it to practice); Cohen, *supra* note 213, at 385–88 (2013).

215. *See* CHISUM ON PATENTS, PART I. TREATISE ON THE LAW OF PATENTABILITY, VALIDITY AND INFRINGEMENT § 2.02(a).

216. *See* 35 U.S.C. § 116 (1952).

217. Joshua Matt, *Searching for an Efficacious Joint Inventorship Standard*, 44 B.C. L. REV. 245, 257 (2002).

ownership rights over the patent regardless of the quantity or quality of their respective contributions.[218]

Early case law was somewhat hostile to collaborative research, although the tide began to turn in 1967 with a much cited case, that of *Monsanto v. Kamp Co.*, that tried to clarify the doctrine in a way that would facilitate collaboration.[219] In 1984, the Patent Act was amended in an effort to respond to "the realities of modern team research" by elaborating on, and liberalizing, the requirements for joint inventorship in an amended § 116[220] that expanded the situations in which joint inventorship might be found.[221] The amendment to § 116 led to the current version of the joint inventorship provision, which tells us that:

> When an invention is made by two or more persons jointly, they shall apply for patent jointly and each make the required oath, except as otherwise provided in this title. Inventors may apply for a patent jointly even though (1) they did not physically work together or at the same time, (2) each did not make the same type or amount of contribution, or (3) each did not make a contribution to the subject matter of every claim of the patent.[222]

While this definition simply indicates what is not required as part of a finding of joint inventorship, case law provides some additional guidelines for determining what types of contributions and what level of collaboration are required in order to find joint inventorship.[223] First, in order to be a co-inventor, each joint inventor must contribute to the conception of the invention.[224] Second, this contribution to the invention must not be

---

218. 35 U.S.C. § 262 (2012).

219. *See* Monsanto v. Kamp Co., 269 F. Supp. 818, 824 (D.D.C. 1967); *see also* discussion of evolution of the doctrine in Fellmeth, *supra* note 173, at 94–106.

220. 130 CONG. REC. 28,069–71 (1984). *See National Productivity and Innovation Act of 1983: Hearing on S.1535 and S.1841 Before the Senate Subcommittee on Patents, Copyrights and Trademarks of the Committee on the Judiciary*, 98th Cong. 68 (1984).

221. *See* 130 CONG. REC. 28,069–71 (1984) (Amendment to 35 U.S.C. § 116). Legislative history suggests that the purpose of this amendment was "to remedy the increasing technical problems arising in team research, for which existing law, deemed to require simultaneous conception as well as shared contribution by each named inventor to every claim, was producing pitfalls for patentees, to no public purpose." 1 JANICE M. MUELLER, MUELLER ON PATENT LAW: PATENTABILITY AND VALIDITY n.44.

222. 35 U.S.C. § 116(a) (2012).

223. *See, e.g.*, Krul, *supra* note 172, at 84–91 (2013); Pannu v. Iolab Corp., 155 F.3d 1344, 1351 (Fed. Cir. 1998).

224. Fina Oil & Chem. Co. v. Ewen, 123 F.3d 1466, 1473 (Fed. Cir. 1997) ("The case law thus indicates that to be a joint inventor, an individual must make a contribution to the conception of the claimed invention that is not insignificant in quality, when that contribution is measured against the dimension of the full invention.").

insignificant in quality when measured against the full invention, and must do more than explain well-known concepts or the current state of the art.[225] Third, some modicum of collaboration is required. "Joint inventorship under section 116 can only arise when collaboration or concerted effort occurs—that is, when the inventors have some open line of communication during or in temporal proximity to their inventive efforts."[226] Fourth, the contribution must be corroborated.[227] Since conception is a mental act, courts will require corroborating evidence to support claims of conception.[228] An inventor's testimony on its own is not enough, alleged co-inventors must produce corroborating evidence of a contemporaneous disclosure sufficient in scope and detail to enable one skilled in the art to make the invention.[229]

Even with these guidelines of contribution to conception and some kind of collaboration or concerted effort, legal determinations of joint inventorship remain "clear as mud."[230] When discoveries emerge from collaborative processes, the guidelines do not provide any bright-line rules. Instead, courts must weigh and balance the contributions of potential inventors to determine whose acts qualify as acts of inventorship and whose acts do not.[231] Although the threshold for finding joint inventorship was lowered by the 1984 amendment, the allocation of equal bundles of rights in the resulting patent to all co-inventors remained unchanged.[232]

While determinations of joint inventorship are difficult to make, the consequences of getting inventorship wrong can be severe. If a co-inventor is not included in the initial patent or is included mistakenly, the burden of showing misjoinder or nonjoinder is imposed on the parties seeking a change to the original inventorship and this burden is a heavy one.[233] This makes it difficult for any wrongfully excluded inventors to obtain their rights. In addition, a patent is invalid unless it lists the true

---

225. *Fina Oil*, at 1473; *Pannu*, at 1351.

226. Eli Lilly & Co. v. Aradigm Corp., 376 F.3d 1352, 1359 (Fed. Cir. 2005).

227. *See, e.g.*, Burroughs Wellcome Co. v. Barr Labs., Inc., 40 F.3d 1223, 1228 (Fed. Cir. 1994) (holding that conception, as a mental act requires corroborating evidence of contemporaneous disclosure).

228. *Id*.

229. Coleman v. Dines, 754 F.2d 353, 360 (Fed. Cir. 1985); Mahurkar v. C.R. Bard, Inc., 79 F.3d 1572, 1577 (Fed. Cir. 1996); Price v. Symsek, 988 F.2d 1187, 1194–95 (Fed. Cir., 1993).

230. *See Burroughs Wellcome*, 40 F.3d at 1223.

231. *Id*. at 1231.

232. Matt, *supra* note 217, at 247, 261.

233. Hess v. Advanced Cardiovascular Sys. Inc., 106 F. 3d 976, 980 (Fed. Cir. 1997) ("Because the issuance of a patent creates a presumption that the named inventors are the true and only inventors . . . the burden of showing misjoinder or nonjoinder of inventors is a heavy one and must be proved by clear and competing evidence.").

inventor(s) of the claimed invention.[234] While the Patent Act allows for the correction of good faith inventorship errors, omitted inventors have the opportunity to provide licenses, and any intentional misnaming of joint inventors can result in unenforceability of the patent due to inequitable conduct.[235]

C. Disconnect between Doctrine and Collaborative Discovery

> "Coming together is a beginning, staying together is progress, and working together is success."
>
> —Henry Ford[236]

The current approach to joint inventorship described above leads to problems of uncertainty about inventorship and to problems of over-inclusiveness and under-inclusiveness in determinations of who shares in the benefits from collaboration. Such problems can lead to higher transaction costs surrounding patenting and use of discoveries, as well as undermining incentives to collaborate. These problems are exacerbated in the types of collaboration contexts described in Part III, where much of the collaborative activity may fall outside of the narrowly defined concept of invention and inventor. While in some cases the parties might be able to reduce these problems through contract, the feasibility of contracting over potential future intellectual property rights in many of the boundary-spanning collaborations discussed in Part III will be extremely limited. Moreover, even where contracts are in place, patent law sets important default rules that influence the bargaining positions of the parties, their incentives to contribute (or not) to the collaboration, and the outcomes in situations of incomplete contracting.

1. Requirement of Identifying True Inventors of an Invention. An inventor-centered approach to patenting cannot easily accommodate organic, cumulative processes of discovery in which there is no single discrete act of discovery but rather the

---

234. *See, e.g.*, Stark v Advanced Magnetics, 119 F.3d 1551, 1556–57 (Fed. Cir. 1997); 35 U.S.C. § 115(a) ("An application for patent that is filed under 111(a) or commences the national stage under 371 shall include, or be amended to include, the name of the inventor for any invention claimed in the application.").

235. Donald A. Degnan & Libby A. Huskey, *Inventorship: What Happens When You Don't Get It Right?*, HOLLAND & HART LLP at 6 (2006) (*available at* https://www.hollandhart.com/files/InventorshipWhatHappens.pdf [https://perma.cc/FS3Y-B3KN]).

236. *21 Quotes from Henry Ford on Business, Leadership and Life*, FORBES (May 31, 2013), https://www.forbes.com/sites/erikaandersen/2013/05/31/21-quotes-from-henry-ford-on-business-leadership-and-life/#1e8d63fb293c [https://perma.cc/K6F9-84BS].

cumulative work and contributions of many participants.[237] Where innovation emerges from the incremental efforts of many contributors, it may be difficult to isolate a specific inventor or group of joint inventors. Moreover, collaborative processes of innovation are often messy and nonlinear, making it difficult to draw boundaries around discrete discoveries. But the patent framework requires drawing clear boundaries between what is background knowledge and not protectable and what is newly created and patentable (the invention), and seeks to identify the mental acts that resulted in the new creations (the inventors).[238]

The need to isolate a particular inventor may create tensions for collaborations that require people to share knowledge with each other and jointly contribute to intellectual production, and may systematically disadvantage groups that engage in collective rather than individual knowledge production. Where inventions emerge from a collective sharing of ideas and knowledge, it may be impossible to identify the true inventors. In addition, this approach does not recognize or reward those who might have been working on the same problem and may have reached the same solution either at the same time or just after the inventors who lay claim to the patent, leading to pressures for secrecy rather than sharing of knowledge.

This approach also draws stark boundaries between intellectual assets that can be patented, and used to extract market rents, and intellectual assets that do not receive patent protection, assets from which it may be difficult to appropriate value. As a result, some contributions and some contributors to collaborative production may be over-rewarded, and others under-rewarded. In the context of user–producer innovation and public–private partnerships, where users and public participants are often sharing what might be considered as background or early stage knowledge, the result may be to systematically disadvantage these groups. This could jeopardize collaborations that require different types of contributions and rely on trust and reciprocity to sustain collaborative efforts.

2. Looking for Contributions to Conception. Determining who has made an inventive contribution is difficult at the best of times. "The statute does not set forth the minimum quality or quantity of contribution required for joint inventorship,"[239] and

---

237. Lee, *supra* note 11, at 28–29 (critiquing need under patent law to find and assign individual rights to invention, poor fit with the communal, organic nature of much innovation).

238. *Id.* at 31.

239. Burroughs Wellcome Co. v. Barr Labs., Inc., 40 F.3d 1223, 1227 (Fed. Cir. 1994).

the Federal Circuit has not provided any explicit lower limit on either the quality or quantity of inventive contribution required.[240] In trying to ascertain what contributions qualify for joint inventorship, the Federal Circuit itself has acknowledged that "[t]he line between actual contributions to conception and the remaining, more prosaic contributions to the inventive process that do not render the contributor a co-inventor is sometimes a difficult one to draw."[241] Existing case law tells us that the contributor must do more than merely explain well known concepts or the current state of the art.[242] Contributing to the reduction in practice of the invention is also not enough to establish joint inventorship.[243] In addition, although some courts have disputed this, the contribution must be to the conception of the claimed invention.[244] On the other hand, a co-inventor need not contribute to every claim, contributing to even one claim may be enough for joint inventorship.[245]

This approach to joint inventorship creates uncertainty about who should and should not be included as joint inventors as well as creating problems of over and under-inclusiveness in determinations of initial ownership over the results of collaboration.

In situations of open, decentralized collaborative user innovation, for example, it may be difficult to identify the players involved and to track the sources of contributions made. Where inventions arise through a decentralized, open process of incremental innovation among users it may even be impossible to identify any single group of participants as the conceivers of the invention, making it impossible to obtain a valid patent for the resulting discovery.

In situations of human–machine collaboration it may be difficult to determine which contributions to the conception of the invention come from the person and which come from the machine.

---

240. *See, e.g.*, Fina Oil & Chem. Co. v. Ewen, 123 F.3d 1466, 1473 (Fed. Cir. 1997).

241. Eli Lilly & Co. v. Aradigm Corp., 376 F.3d 1352, 1359 (Fed. Cir. 2004) (discussing the challenge of drawing the line between contributions that qualify for inventorship and those that don't, noting "it is quite possible to interpret the court's language to deprive legitimate inventors of recognition for their contributions.").

242. *Aradigm Corp.*, 376 F.3d at 1359 (Fed. Cir. 2004); Pannu v. Iolab Corp., 155 F.3d 1344, 1351 (Fed. Cir. 1998).

243. Fellmeth, *supra* note 173, at 109.

244. *See, e.g.*, *Aradigm Corp.*, 376 F.3d at 1359 (Fed. Cir. 2004) ("[A] person is a joint inventor only if he contributes to the conception of the claimed invention."); *see also* MPEP § 2137.01, Inventorship (8th ed. Rev. 7, Sept. 2008) ("The inventive entity for a particular application is based on some contribution to at least one of the claims made by each of the named inventors.").

245. Fellmeth, *supra* note 173, at 107.

Patent law currently does not provide a way of recognizing the inventive contributions of the machine, and there is no current patent law guidance as to how to handle an invention that is invented either solely by a machine or jointly by a person and a machine.[246] There is also no patent law guidance on whether ignoring the role of the machine in a patent for an invention co-created by a person and a machine would make the patent invalid for failure to state the true inventors.[247]

In situations of public–private partnerships, where public participants are often in the position of providing early stage research that industry partners translate into commercial products, the contributions from the public participants may often be found to be non-inventive contributions despite their value—particularly where the analysis focuses on the claims of the resulting patent. Recent case law has emphasized the importance of showing that a joint inventor has contributed to the conception of a claimed invention, which may exacerbate the disadvantage to the public partners.[248] A fixation on contribution to the conception of the claim could have particularly negative consequences for academic researchers or individual users working with industry partners, since a combination of differences in the nature of contributions and careful claims drafting can be used by industry partners to exclude research collaborators as co-inventors.[249]

3. A Modicum of Collaboration. In addition to establishing contributions to the conception of the claimed invention, putative joint inventors must also show some "quantum of collaboration or connection."[250] "For persons to be joint inventors under § 116, there must be some element of joint behavior, such as collaboration or working under common direction, one inventor seeking a relevant report and building upon it or hearing another's suggestion at a meeting."[251] The degree of collaboration is fairly low, only requiring some slight form of awareness and direct or indirect communication of the co-inventors. The requirement has been described as requiring "two or more persons working toward

---

246. Abbott, *supra* note 155, at 1099.

247. *Id.* at 1099.

248. *See* Fellmeth, *supra* note 173, at 134 (arguing that relying exclusively on claims rather than on a broader conception of invention to determine joint-inventorship leads to unfairness, confuses basic patent doctrine, and undermines incentives to collaborate, describes situations in which current claims-based approach will reduce incentives of universities to collaborate with pharmaceutical companies).

249. *See id.* at 134.

250. Kimberly-Clark Corp. v. Procter & Gamble Distrib. Co., 973 F.2d 911, 917 (Fed. Cir. 1992).

251. *See id.* at 1925–26; MPEP § 2137.01, Inventorship (8th ed. Rev. 7, Sept. 2008).

the same end and producing an invention by their aggregate efforts."[252]

Many forms of boundary-spanning collaboration involve multiple participants who share a common goal, at least at some level, and who are involved in a system of direct or indirect information sharing, although they are not working under common control. The process for determining whether there has been sufficient collaboration or coordination is fact intensive, leading to uncertainty as to when joint inventorship will be found.[253] The required coordination is very low, however, suggesting that this threshold at least will be relatively easy to establish.[254] This means that under even very decentralized forms of collaboration, participants in a collaborative process may find themselves to be co-inventors whether intended or not. Given the consequences of joint inventorship—equal rights to the resulting invention—this criterion may lead to an over-inclusiveness in joint inventorship determinations.

4. Lack of Connection between Contributions and Rewards. The need to find and define a discrete new invention may be difficult to satisfy where knowledge processes are cumulative in nature, building on existing knowledge and new ideas in ways that blend together what is already known and what is new. In boundary-crossing collaborations, parties are often contributing different types of knowledge and ideas, only some of which will constitute inventive contributions, leading to potential inequities in the allocation of rewards that patents produce.

Inequities can arise even for those participants who do make inventive contributions to a patentable invention. Once established as a joint inventor, each inventor has equal ownership in all claims, including those to which the inventor did not contribute.[255] Where there is a large divergence in the magnitude of the contributions, this can have the consequence of giving the most important contributor to an invention the same rights as the least important, with possibly negative incentive effects on collaboration.[256] In collaborations that span different types of

---

252. *See, e.g.*, Monsanto Co. v. Kamp, 269 F. Supp. 818, 824 (D.D.C. 1967).

253. *The Muddy Collaboration Element of Joint Inventorship*, LAW360 (Nov. 20, 2010), https://www.law360.com/articles/192274 [https://perma.cc/W72L-HU4Z].

254. Fellmeth, *supra* note 173, at 96–97.

255. *See* Ethicon Inc. v. U.S. Surgical Corp., 135 F.3d 1456, 1471–72 (Fed. Cir. 1998).

256. *See, e.g.*, Gregory Mandel, *Left-Brain versus Right-Brain: Competing Conceptions of Creativity in Intellectual Property Law*, 44 U.C. DAVIS L. REV. 283, 294–95 (2010) (highlighting problems with skewed inventorship rewards resulting from the presumed equal ownership for unequal contributions, proposes giving proportional rights to joint inventors where contributions of varying levels are made); D. Carlson & J. Barney, *The*

innovation communities, the likelihood of divergence in quality and quantity of contributions is likely to be large while the ability to deal with divergent contributions ex ante through contract is likely to be low. The failure to adequately capture and reward more valuable contributions can have negative effects on the incentives of lead innovators to participate.

Collaborations emerge from the fluid sharing and use of knowledge and information in ways that fit poorly with this focus on the exclusive rights of the inventor.[257] The incentives that patents create can create tensions between different knowledge communities as they seek to work together, particularly where some of the participants are motivated by non-market motivations while others are motivated by market motivations. Moreover, the focus of the patent system is on the rights of the inventor, with little attention to the rights of the users and the social benefits of use.

5. Problems of Corroboration. While firms may require their inventor-employees to keep records and monitor the data that they share and the contributions that they make, and may have processes for following up ideas with some kind of written record—such as a draft patent application—none of these practices are common in open, collaborative systems of user innovation.[258] Public–private partnerships involving a combination of academic researchers and industry participants may run into the same problems, as academics are constantly participating in conferences and sharing their ideas with each other as they move between labs and across projects. This requirement may lead to a systematic bias in favor of firms who participate in cross-boundary collaborations, an advantage that may be compounded by the benefits of being the first to file a patent (something commercial participants are most likely to do) and the presumptions of validity that accompanies the issued patent.

As the above analysis suggests, joint inventorship doctrine is not designed to handle the types of collaborative discoveries that boundary-spanning collaborations are likely to generate. Given that joint inventorship doctrine remains the primary vehicle for

---

Division of Patent Rights Among Joint Inventors: Public Policy Concerns After Ethicon v. US Surgical, 39 IDEA 251, 255 (1999).

257. *See, e.g.*, Dreyfuss, *supra* note 5, at 402 (discussing disconnect between IP laws and the needs of collaborative research); Strandburg, *supra* note 20, at 239–40 (discussing the challenges that patents create for groups that have opted out of IP).

258. Strandburg, *supra* note 20, at 235 (discussing differences between user innovation and formal intellectual property).

dealing with collaborative discoveries within patent law, this suggests that patent law is also not adequately designed to handle the types of collaborative discoveries that boundary-spanning collaborations are likely to generate.

V. CONCLUSION

This Article has highlighted some of the ways in which heterogeneous forms of collaborative innovation stress the current patent law framework. It has focused on the limitations that result from patent law's reliance on the joint inventorship doctrine to accommodate the modern day needs and realities of collaborative invention. In a world where boundary-spanning collaborations are increasingly the norm rather than the exception in intellectual production, the Article concludes that it is time for patent law and policy to take the social context of innovation into greater account, and it points to the joint inventorship doctrine as a good place to start.