Berkeley Technology Law Journal

Volume 32
Issue 5 *Issue 4*

Article 6

5-28-2018

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Recommended Citation

David J. Teece, *THE "TRAGEDY OF THE ANTICOMMONS" FALLACY: A LAW AND ECONOMICS ANALYSIS OF PATENT THICKETS AND FRAND LICENSING*, 32 Berkeley Tech. L.J. 1489 (2018).

Link to publisher version (DOI)

https://doi.org/10.15779/Z38RR1PM7N

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Cover Page Footnote
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THE "TRAGEDY OF THE ANTICOMMONS" FALLACY: A LAW AND ECONOMICS ANALYSIS OF PATENT THICKETS AND FRAND LICENSING

David J. Teece†

ABSTRACT

Heller introduced the "anticommons" concept in the late 1990s, based on Hardin's earlier "commons" concept, to refer to the situation in which numerous entities control the rights to use some asset or related cluster of assets. Heller and Rosenberg argued that, in such situations, users would need permission from multiple rights holders in order to use the asset(s), and that the difficulties of coordination would lead to inefficient underuse, leading to what they termed the "tragedy of the anticommons." This Article addresses the limitations of the "tragedy of the anticommons" arguments in the context of licensing of patents related to some industry standard for which the patent holders have committed to license their patents on "fair, reasonable and nondiscriminiatory" ("FRAND") licensing terms. This Article identifies several real–world examples where Heller and Eisenberg's prediction of underuse are not borne out in practice, and explain why real–world institutions that have emerged have largely solved the problem.

DOI: https://doi.org/10.15779/Z38RR1PM7N

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I. INTRODUCTION

The idea of the "anticommons" was introduced to the law and economics literature by Heller (1998)[1] and Heller and Eisenberg (1998)[2] using an analogy with Hardin's "tragedy of the commons."[3] They suggested that, when ownership of complementary assets (whether tangible or intangible) is fragmented, firms may not be able to negotiate for all of the

1. Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621 (1998).

2. Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698, 698–701 (1998).

3. Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243 (1968).

permissions needed to use the fragmented rights in socially desirable ways.[4] The claim is that, when ownership of rights is fragmented, the difficulties associated with negotiating the necessary permissions lead to inefficient underuse.[5] Heller and Eisenberg point to the situation in biomedical research, where many firms have different patents on complementary research tools whose coordinated use is needed to discover, develop, and market new drugs.[6]

Heller defined the anticommons as a situation on which "multiple owners are each endowed with the right to exclude others from a scarce resource, and no one has an effective privilege of use."[7] He gave as his example the situation in post–Soviet Russia in which storefronts sat idle while vendors set up kiosks on the sidewalk in front of the empty storefront, because the rights to control the use of the building were held by a group of different entities and negotiating the necessary permissions to use the building was difficult.[8] In that situation, the "scarce resource" is the building, and the tragedy is that a valuable asset can be underused, not used, or possibly even abandoned.

As noted, Heller and Eisenberg applied the anticommons label to a quite different situation in which multiple patent holders each have separate patents on various complementary biotechnology research tools, a number of which need to be used together in order to develop new products legally.[9] However, in such a situation, it is doubtful whether there is a single "scarce resource" over which "multiple owners" each have the right to exclude. Instead, there are multiple complementary patents; each patent holder has the right to exclude others from using its own patented technology (but not

4. Heller, *supra* note 1, at 624 ("When there are too many owners holding rights of exclusion, the resource is prone to underuse—a tragedy of the anticommons"); Heller & Eisenberg, *supra* note 2, at 698 ("[A]voiding tragedy requires overcoming transaction costs, strategic behaviors, and cognitive biases of participants . . . Once an anticommons emerges, collecting rights into usable private property is often brutal and slow.") (citations omitted).

5. *See supra* note 4 and accompanying text.

6. Heller & Eisenberg, *supra* note 2, at 698 ("The result has been a spiral of overlapping patent claims in the hands of different owners, reaching ever further upstream in the course of biomedical research.").

7. Heller, *supra* note 1, at 624.

8. *Id.* ("This Article proposes empty Moscow storefronts as a canonical example of the tragedy of underuse."). In reality, one expects that it may have been either a plethora of regulations or difficulty in pricing the various permissions rather than fragmentation of property rights that stood in the way of easy use.

9. Heller & Eisenberg, *supra* note 2.

the others' patents), and users need to use multiple complementary patented technologies in order to develop and legally market new products.[10]

In what follows, I will use the latter interpretation (i.e., that market activity is complicated by the challenges associated with what I call elsewhere the "multi–invention" situation).[11] Given this interpretation, I believe that the presence of "patent thickets"—where multiple patents held by different firms are often required for completion of a single product—would be an example of the anticommons "problem," as Heller and Eisenberg framed it in their discussion of the anticommons in biomedical research.[12]

Experience does not bear out Heller and Eisenberg's anticommons thesis in the patent context. In many situations where multiple patents covering many products in many contexts, there are extraordinary rates of innovation despite the fact that barriers supposedly exist.[13] This should give immediate pause to anyone trying to understand whether or not there is a policy issue of the kind Heller and Eisenberg suggest with respect to the so–called "anticommons." As discussed below, one can seriously question whether the "anticommons tragedy" arises all that frequently. Every day, many firms face the challenge of assembling thousands of inputs to make complex systems. The existence of products that require licenses from multiple patent owners supposedly leading to what Heller and Eisenberg characterize as a "tragedy of the anticommons" does not, in practice, seem to lead to serious problems.

Empirical work appears to confirm this commonsense intuition. For example, one study by Walsh, Arora, and Cohen did not show support the anticommons tragedy thesis for biotech.[14] Instead, they found that patents

10. Deepak Somaya, David Teece & Simon Wakeman, *Innovation in Multi-Invention Contexts: Mapping Solutions to Technological and Multi-Invention Complexity*, 53 CAL. MGMT. REV. 47 (2011).

11. Somaya et al., *supra* note 10.

12. Edward J. Egan & David J. Teece, *Untangling the Patent Thicket Literature* (Tusher Cent. for Mgmt. of Intellectual Capital, Working Paper No. 7, 2015), http://innovation-archives.berkeley.edu/businessinnovation/documents/Tusher-Center-Working-Paper-7.pdf.

13. One well–known example includes cellular telecommunications, where there are thousands of patents held by hundreds of firms that have been declared as essential to various cellular standards, but the pace of technological progress is extremely rapid. *See infra* Section II.F.

14. John P. Walsh, Ashish Arora & Wesley M. Cohen, *Effects of Research Tool Patents and Licensing on Biomedical Innovation*, *in* PATENTS IN THE KNOWLEDGE-BASED ECONOMY 285, 285 (Wesley M. Cohen & Stephen A. Merrill eds., 2003) ("[T]here has in fact been an increase in patents on the inputs to drug discovery ('research tools'). However,

only posed a relatively small number of obstacles.[15] Further, the "solutions" to these obstacles included licensing, doing the research beyond the reach of patents, and outright infringement.[16] In addition to the Walsh et al. study, Fiona Murray and Scott Stern (2007) see little evidence of harmful effects created by patent thickets.[17] Their test examines knowledge difference rates associated with the publication of a patent.[18] Anticommons theory predicts a drop–off in citations to the research once patents are granted; they find at most only a modest drop off.[19]

There is a problem of a different kind lurking about that is highlighted in this Article. The systematic problem identified here is undercompensation, and possibly overuse, not underuse. The goal of this Article is to explore in more detail the reasons why underutilization of technology might arise in particular contexts. Indeed, as discussed below, even Eisenberg has subsequently conceded that important qualifications need to be made to the anticommons thesis, noting that unauthorized use likely mitigates the risk of anticommons problems.[20] However, she still worries that in the case of "practically excludable" materials and data, high transaction costs makes technology use less likely.[21]

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we find that drug discovery has not been substantially impeded by these changes. We also find little evidence that university research has been impeded by concerns about patents on research tools.").

15. *Id.* at 285–86 ("Restrictions on the use of patented genetic diagnostics, where we see some evidence of patents interfering with university research, are an important exception. There is, also, some evidence of delays associated with negotiating access to patented research tools, and there are areas in which patents over targets limit access and where access to foundational discoveries can be restricted.").

16. *Id.* at 286 ("[F]irms and universities have been able to develop 'working solutions' that allow their research to proceed.").

17. Fiona Murray & Scott Stern, *Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-Commons Hypothesis*, 63 J. ECON. BEHAV. & ORG. 648 (2007).

18. *Id.* at 650.

19. *Id.* at 651 ("[T]here is robust evidence for a quantitatively modest but statistically significant anti-commons effect; across different specifications, the article citation rate declines by approximately 10 to 20 percent after a patent grant.").

20. Rebecca S. Eisenberg, *Noncompliance, Nonconformist, Nonproblem? Rethinking the Anticommons in Biomedical Research*, 45 HOUS. L. REV. 1059, 1098 (2008).

21. *Id.* at 1098–99.

II. EMPIRICAL AND THEORETICAL CHALLENGES TO THE ANTICOMMONS

Heller and Eisenberg have described a potential concern; but in their original article they did not identify a single verifiable instance of underuse. Instead, their article was replete with examples of what "could" or "may" happen. If research is presented as policy relevant, vague innuendo or occasional examples of allegedly deterred behavior are not an adequate substitute for broader empirical studies.

Accordingly, this Part outlines various empirical and theoretical challenges to the anticommons thesis as articulated by Heller and Eisenberg. It first notes when anticommons scholars claim that an anticommons situation should arise. Then, it identifies five arguments demonstrating that anticommons situations do not inherently give rise to inefficiency or other harmful consequences, and then even when potential anticommons problems may exist, private ordering can effectively solve them.

A. IDENTIFYING "ANTICOMMONS" SITUATIONS

This Section briefly examines the anticommons literature to identify what factors are supposed to give rise to anticommons situations, in order to frame the empirical inquiries in the remainder of this Part. As noted in Part I, the anticommons literature is thought to have started with Heller and Eisenberg. Since their papers, a number of other authors have expanded on their work, notably Buchanan and Yoon[22] and Fennell.[23] Buchanan and Yoon purport to show that the anticommons and commons problems are symmetric, though I disagree for the reasons laid out below.[24] Fennell contrasts both the commons and the anticommons with what she refers to as the "semicommons," following Henry Smith's work.[25]

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22. James M. Buchanan & Yong J. Yoon, *Symmetric Tragedies: Commons and Anticommons*, 43 J.L. ECON. 1 (2004).

23. Lee Anne Fennell, *Commons, Anticommons, Semicommons*, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW 35 (Kenneth Ayotte & Henry E. Smith eds., 2009) (citing Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 29 J. LEGAL STUD. 131 (2000)).

24. The core problem with their argument is that even though, on paper, multiple permissions are needed in order to make use of complementary assets, this "requirement" often does not hold true in practice once the limitations of defining and enforcing rights are recognized. *See infra* Section II.C.

25. Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 23 J. LEGAL STUD. 131 (2000).

In what follows, I will concentrate on Heller and Heller and Eisenberg. As noted above, one particularly important example of a situation where there are fragmented property rights involves so–called "patent thickets," where numerous firms have a large number of patents that relate to some product. I have written critically about patent thickets at length elsewhere and will not repeat that discussion here.[26] The presence of patent thickets has led to concerns about "royalty stacking," a situation in which the potential for having to pay multiple patent holders for licenses is claimed to raise the cost of making products, potentially to unsustainable levels.[27] The issue of "royalty stacking" is a complex one, but a discussion of the issues involved would take us too far afield from the thrust of the present Article.

Finally, in some contexts, patent holders have voluntarily given pledges not to enforce their patents.[28] One recent example involves Tesla's pledge not to assert its patents against those that want to use its technology in good faith.[29] Such pledges may serve to reduce problems associated with the potential enforcement of patent rights. However, because there is a dearth of aggregated empirical data to analyze, this Article does not engage with them.[30]

26. *See, e.g.*, Edward F. Sherry & David J. Teece, *Patent Thickets: An Economic Appraisal* (Tusher Cent. for Mgmt. of Intellectual Capital, Working Paper No. 1, 2015), http://innovation-archives.berkeley.edu/businessinnovation/documents/Patent-Thickets232015.pdf; Egan & Teece, *supra* note 12.

27. Benjamin C. Li, *The Global Convergence of FRAND Licensing Practices: Towards "Interoperable" Legal Standards*, 31 BERKELEY TECH. L.J. 429, 432 (2016) ("A royalty rate that may have seemed reasonable on its own is not reasonable when a company developing a particular technology must pay several thousand separate royalties to account for all of the patents implicated by its technology. Stacking all of these royalties on top of each other can make a product too expensive to bring to market."); Zelin Yang, *Damaging Royalties: An Overview of Reasonable Royalty Damages*, 29 BERKELEY TECH. L.J. 647, 652 (2014) ("The cumulative effect of potentially overcompensating thousands of patentees represents a crushing cost for producers and stifles innovation."); Mark A. Lemley & Carl Shapiro, *A Simple Approach to Setting Reasonable Royalties for Standard-Essential Patents*, 28 BERKELEY TECH. L.J. 1135, 1149 (2013) ("Royalty stacking arises when implementers must pay royalties to multiple patent owners, so those royalties cumulate or 'stack' on top of each other from the perspective of the implementer.").

28. *See generally* Clark D. Asay, *The Informational Value of Patents*, 31 BERKELEY TECH. L.J. 259 (2016) (describing the legal implications of the growing trend of patent nonenforcement pledges).

29. *See id.* at 280 (noting that it is an open question whether such pledges would be enforceable in a lawsuit); Tyrone Berger, *Where's the Real Value in Tesla's Patent Pledge*, PHYS.ORG (Aug. 20, 2014), http://phys.org/news/2014-08-real-tesla-patent-pledge.html.

30. Unfortunately, I do not know of any data source that collects information about the extent of such pledges in different industries, nor of any data source that would enable me to trace the empirical effect of such pledges.

B. COMPLEX PRODUCTS WITH MANY TANGIBLE INPUTS SUPPLIED BY DIFFERENT SUPPLIERS

There are readily observable situations where an anticommons problem should arise under Heller and Eisenberg's theory, but does not arise in practice. To better understand the nature of a possible anticommons problem, I believe it is worth drawing an analogy to the situation in which multiple tangible complementary inputs supplied by a large and "fragmented" number of different suppliers are needed to make and sell a complex product.

By way of illustration, Boeing says that that "the 787 [Dreamliner] is made up of 2.3 million parts, which are flown in from 135 sites across the globe"[31] presumably sold by hundreds if not thousands of suppliers. One source says that an "A380 [Airbus] has about 4 million parts, with 2.5 million part numbers produced by 1,500 companies from 30 countries around the world."[32]

To my knowledge, no one complains about an "anticommons" in the supply of airplane parts, but the situation certainly qualifies as an "anticommons" in the Heller and Heller and Eisenberg sense. The aircraft manufacturers need to assemble numerous (in this case, millions of) complementary inputs (in this case, tangible components), supplied by a large and "fragmented" group of suppliers, in order to make and sell its product. Boeing and Airbus have to negotiate with hundreds if not thousands of vendors to acquire the necessary millions of parts.[33] Once production commences, if any key input from a key supplier is unavailable, the production process grinds to a halt, even if all of the other inputs are available. Yet airplane production and innovation proceeds apace.[34] Neither the fact that there are multiple suppliers of needed complementary components or the potential for "input cost stacking" acts as a deterrent to making and selling complex products. This is also true despite the fact that some components are proprietary and do not enter general commerce.

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31. Lucy Tobin, *Dreaming Big in Boeing's Jumbo Factory*, INDEPENDENT (Apr. 16, 2014, 11:00 PM), http://www.independent.co.uk/news/business/analysis-and-features/dreaming-big-in-boeings-jumbo-factory-9265916.html; Randy Tinseth, *Our Supply Chain*, BOEING BLOGS (Feb. 21, 2013), http://www.boeingblogs.com/randy/archives/2013/02/supply_chain.html (offering a visual breakdown of suppliers for the Boeing 787).

32. James Wallace, *A380 Ride & Factoids*, SEATTLE POST-INTELLIGENCER (Mar. 29, 2007, 5:03 PM), http://blog.seattlepi.com/aerospace/2007/03/29/a380-ride-and-factoids/.

33. *See id.*; Tobin, *supra* note 31; Tinseth, *supra* note 31.

34. William Cook, *The Best Innovation in Aviation*, BBC FUTURE (Dec. 19, 2017), www.bbc.com/future/story/20171219-subtle-and-surprising-innovations-in-aviation.

In fairness, the lack of concern may be because of competition among vendors of parts to supply parts to Boeing or Airbus; if one hydraulic pump supplier tries to charge an excessive price, Boeing or Airbus can turn to an alternative pump supplier. That is often not the case with patented technology, as each patent holder has a "monopoly" over its own patented technology (though there may be just–as–good substitute technologies available from others; so the "patent monopoly" over a particular patented technology may not imply any market power in a relevant technology market).[35] The lack of concern is also in part because tangible input suppliers can physically withhold their inputs unless assured of payment, unlike patent holders who have to resort to costly and risky patent litigation to enforce their rights. Finally, the lack of concern may also be because tangible inputs are often priced differently from intangible patented inputs; patent royalties calling for the licensee to pay a percentage–based royalty on its sales are common,[36] but I have never seen such a pricing structure for tangible inputs used to make a complex product.

Despite these caveats, the point is that the mere presence of an "anticommons" does not always lead to "underuse," contrary to the suggestion of Heller and Eisenberg. Airplane production is a situation in which supply of complementary inputs needed for a complex product is fragmented, so that an implementer needs to deal with hundreds if not thousands of suppliers of complementary inputs—yet there is no resultant failure to provide air travel, as the robust and innovative airline industry demonstrates. Further, it obviously costs more to buy the millions of parts needed for an airliner than the dozens of parts needed for, say, a bicycle, and transaction costs are higher when there are more input suppliers. But in my experience, the "input cost stacking" in the case of multiple tangible inputs does not raise the hackles of commentators to anywhere near the

35. *See* Justin R. Orr, *Patent Aggregation: Models, Harms, and the Limited Role of Antitrust*, 28 BERKELEY TECH. L.J. 525, 557 (2013) ("A patent alone does not convey market power for the purposes of antitrust law, and courts generally assume that because any inventor can innovate and receive a patent, firms rarely possess market power in a market for patents themselves."); Stuart J.H. Graham & Ted Sichelman, *Why Do Start-Ups Patent?*, 23 BERKELEY TECH. L.J. 1063, 1085 n.99 (2008) (calculating that only "about 10% of all patents confer significant market power"); *but cf.* Thomas H. Chia, *Fighting the Smartphone Patent War with RAND-Encumbered Patents*, 27 BERKELEY TECH. L.J. 209, 211 (2012) ("Entities that implement a closed standard are 'locked in' to the patents that are essential to the standard. As a result, these 'essential patent[s]' automatically confer market power onto the patent holder.").

36. Yang, *supra* note 27, at 648 (noting that such royalties "are the most common form of damages, accounting for eighty-one percent of the damages awards" in patent cases).

same degree that the somewhat–analogous "royalty stacking" does in the case of multiple patented inputs. In short, the process of production for an airline shows that an "anticommons" can exist without limiting innovation and development.

C. INFRINGEMENT, ACCESS, AND SELF–ENFORCEMENT

Anticommons situations may not give rise to inefficiencies when parties have access to patented goods and strategically choose to infringe. The tacit assumption underlying much of the Heller and Eisenberg anticommons argument is that firms need to negotiate in advance for the permissions needed to make and sell products.[37] That may be the case in the context of physical inputs, where all of the complementary inputs to a complex product are needed in order to assemble the product and the suppliers of the physical inputs will not deliver those inputs unless they are assured of getting paid.

But the situation with patents is different. This is because patent holders cannot physically withhold their patented technology from implementers who have not paid for the right to use it; instead, patent holders have to resort to costly and risky litigation in order to protect their rights.[38] As noted earlier, patents are not self–enforcing—they never have been. Accordingly, firms can and routinely do use patented technology without permission,[39] though of course they run the risk that they may be sued for doing so, may have to pay the (not inconsiderable) costs of defending against such suits, and may (if, but only if, the patent is found valid and infringed) be required to pay damages for their infringement and may be enjoined from future infringement if the court decides to grant an injunction.

Patent injunctions have also grown more difficult to obtain over time. In the days prior to the landmark *eBay* decision,[40] post–verdict prospective injunctions were routinely granted; now, the courts apply a four–factor test in deciding whether to grant such injunctions.[41] Accordingly, injunctions

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37. *See supra* note 4 and accompanying text (noting where Heller and Eisenberg make those assumptions).

38. Walsh et al., *supra* note 14, at 324 (noting that some actors, like universities, "simply to ignore some or all" of the "restrictive patents on upstream inventions" in hopes that an infringement suit will not follow); Tina Saladino, *Seeing the Forest Through the Trees: Gene Patents & the Reality of the Commons*, 26 BERKELEY TECH. L.J. 301, 321 (2011) ("Generally, for-profit firms do not threaten infringement action for unlicensed use largely due to the high costs and limited damages available through litigation.").

39. *See id.*

40. eBay Inc. v. MercExchange, L.L.C., 547 U.S. 388 (2006)

41. *Id.* at 390; Joshua D. Sarnoff & Christopher M. Holman, *Recent Developments Affecting the Enforcement, Procurement, and Licensing of Research Tool Patents*, 23 BERKELEY TECH. L.J. 1299, 1347 (2008) ("*eBay* rejected this strong presumption in favor

are much harder for patent owners to secure. Thus, unlicensed use and infringement is likely more frequent.[42] This is a quite different kind of tragedy from what Heller and Eisenberg had identified, and it may well be the more serious one.

Even Professor Eisenberg is having second thoughts. In a 2008 article, she revisited the anticommons issue in the context of biomedical research, drawing on empirical research (in the form of surveys and interviews) of problems faced by practitioners, both academic and industrial, in the field of biomedical research.[43] She largely retracted many of the "underuse" claims she and Heller had expressed ten years earlier.[44] She drew the distinction between "upstream" research, largely conducted by academics, and "downstream" research, largely conducted by firms, finding more concerns at the "downstream" level than at the "upstream" level.[45] Her conclusion was that:

> [O]verall, intellectual property has presented fewer impediments than policymakers may have projected on the basis of early salient controversies. Most scientists report no difficulties in attempting to acquire IP-protected technologies, and only a small percentage report significant delays in research or having to abandon a project because of IP issues.[46]

She noted that many researchers (especially academics) ignore patents entirely. "Even in fields characterized by extensive patenting, many academic researchers seem to be either oblivious to the patents they might be infringing or unconcerned about potential infringement liability."[47] This may be in part because patent holders often do not learn about such infringement (taking place as it does in research labs largely away from public scrutiny), and in part because patent holders are generally not willing to incur the cost of litigating their patents when there is little prospect of

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of granting injunctions in patent cases, holding that nothing in the Patent Act suggested that patent law should depart from traditional principles of equity law . . . .").

42. Saladino, *supra* note 38, at 321 ("Patent law, itself, may encourage this practice of unlicensed use.").

43. Eisenberg, *supra* note 20.

44. *Id.* at 1098.

45. *Id.* at 1077 ("In the United States, difficulties in attempting to acquire IP-protected technologies were more common among industry respondents (40%) than among academic respondents (25%)."). It is worth noting that the patent situation is the same in both areas.

46. *Id.* at 1061.

47. *Id.*

recovering significant damages (which would be unlikely against academic researchers).[48]

Eisenberg went on to note that other considerations, such as the need to negotiate material transfer agreements (MTAs), proved more problematic for researchers than did patent rights, largely because researchers needed physical access to such raw materials and could not obtain them without negotiating with their suppliers, who (unlike patent holders) can generally physically withhold them unless compensated.[49] She noted the importance of what she called the "burden of inertia"[50] and the distinction between patent rights and what Cohen and Walsh had termed "practical excludability."[51] In these regards, her 2008 paper mirrored those of other scholars, notably Caulfield, Cook-Deegan, Kieff, and Walsh.[52]

The leitmotif of Heller and Eisenberg is that the problem was underuse of technology, not overuse or underpayment. However, if one paid attention to the fact that property rights are not self–enforcing, the fact that (on paper) an implementer needs permissions from a fragmented set of multiple rights holders need not be controlling, as it is costly and difficult to enforce rights, and many implementers will simply ignore the need to obtain all of the necessary permissions. Even putting evidence to one side, the problem with the use of intellectual property knowledge more generally is free riding, imitation, and misappropriation—appropriability is a major challenge, and (in my view) a much more compelling problem than underuse.[53] Poor appropriability denies inventive and creative entities a sufficient return on their activity, and suffocates incentives to engage in inventive activity.[54]

48. *Id.* at 1062.

49. *Id.*

50. *Id.* at 1086.

51. *Id.* at 1085.

52. Timothy Caulfield, Robert M. Cook-Deegan, F. Scott Kieff & John P. Walsh, *Evidence and Anecdotes: An Analysis of Human Gene Patenting Controversies*, 24 NATURE BIOTECHNOLOGY 1091 (2006).

53. Peter S. Menell & Ben Depoorter, *Using Fee Shifting to Promote Fair Use and Fair Licensing*, 102 CALIF. L. REV. 53, 60 n.27 (2014); Robert P. Merges, *A Transactional View of Property Rights*, 20 BERKELEY TECH. L.J. 1477, 1484 n.18 (2005) (describing the importance of appropriability for generating innovation); Arti K. Rai, *Fostering Cumulative Innovation in the Biopharmaceutical Industry: The Role of Patents and Antitrust*, 16 BERKELEY TECH. L.J. 813, 829 & n.64 (2001); Thomas M. Jorde & David J. Teece, *Innovation, Cooperation and Antitrust*, 4 BERKELEY TECH. L.J. 1, 6 (1989) (explaining the differences between—and significance of—weak appropriability versus strong appropriability).

54. *See supra* note 53.

D. PATENTS, THE ANTICOMMONS, AND THE COASE THEOREM

It is also important to note the anticommons thesis runs somewhat counter to the Coase Theorem.[55] (Heller and Eisenberg were silent with respect to its existence or applicability to the predicament they were postulating.) The Coase Theorem claims that at least when (a) property rights are well defined and their ownership is agreed upon and (b) transactions costs are zero, parties will negotiate to an efficient outcome.[56] When these conditions hold, the theorem indicates that private ordering should solve any anticommons predicament without the need for government intervention.[57] Put another way, if the Coase conditions hold, the fact that the ownership of relevant rights is fragmented and that multiple permissions are (at least on paper) needed does not lead to inefficiencies; there is no "tragedy."[58] However, even if the Coase conditions are not satisfied, there are yet other ways in which private ordering (i.e., voluntary private contractual arrangements) may be able to lead to the resolution of issues that might arise.[59] These are discussed below.

In the context of patents, the dual assumptions that (1) rights are well defined and (2) assignment of rights to particular parties are agreed upon by all interested parties are seriously questionable and sometimes inapplicable. While the *existence* of patents is generally agreed to (though many firms are not aware of others' patent rights), there is often significant disagreement as to the parties' respective rights and obligations.[60] The patent holder may

55. R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1 (1960).

56. *Id.* at 19; *see also* Merges, *supra* note 53, at 1480–81 (describing the refinement of Coase's work, including the Coase Theorem, over time).

57. *See supra* note 56.

58. Heller and Eisenberg themselves seem to implicitly recognize the implications of the Coase conditions holding. *See* Heller & Eisenberg, *supra* note 2, at 698 ("In theory, in a world of costless transactions, people could always avoid commons or anticommons tragedies by trading their rights.") (citation omitted).

59. The Coase Theorem does not imply that parties will always negotiate to a successful agreement. If the potential seller values the item being negotiated over more than the potential buyer does, there is no mutually acceptable deal; the "no deal" outcome is economically efficient. Most "potential" transactions never occur because the potential buyer is unwilling to meet or exceed the potential seller's reservation price. Only when there are gains from trade would one expect to see a transaction.

60. That said, many implementers intentionally choose not to look for potentially relevant patents related to their activities, often out of concerns that, if they have identified a potentially relevant patent, they may be required to pay up to treble damages for unlicensed "willful infringement" should the patent be found valid and infringed. J. Jonas Anderson, *Secret Inventions*, 26 BERKELEY TECH. L.J. 917, 941 (2011) (describing the disclosure–based "teaching function" of patents as "ineffective" because of "the risk of willful infringement faced by those that do examine prior patents"); Mark A. Lemley &

believe that its patent is valid and infringed by another's product; the other party may dispute the patent's validity, infringement, or both. Infringement often turns on how the claims of the patent are construed and interpreted (which involves an often–disputed process called "claim construction").[61] Resolving these disagreements is costly and time consuming.

Several empirical studies of patent litigation outcomes show that only about half of litigated patents are found valid and infringed.[62] Indeed, economists acknowledge that patents are only "probabilistic,"[63] in the sense that, in any given context, there is only some probability that the patent will (if litigated) be found valid and infringed by some product. The situation is complicated even if the parties *agree* on these probabilities, but the parties often *disagree* on the probabilities of validity and infringement. Theory suggests that, if the patent holder is more optimistic that the accused infringer about the probability that the patent, if litigated, would be found valid and infringed, then the patent holder will (holding other factors constant) want to be paid more for a license than the accused infringer is willing to pay, so that no mutually agreeable deal can be reached. Conversely, if the situation is reversed and the patent holder is less optimistic than the accused infringer, it is more likely that a mutually agreeable deal can be reached. The fact that patents are probabilistic, and that the parties often disagree on the probability that a court would find the patent valid and infringed, makes relying on the Coase Theorem suspect.

The Coase Theorem identifies sufficient, not necessary, conditions for negotiations to lead to efficient outcomes. As noted above, if property rights are well defined and their assignments are agreed to, and if transactions costs are zero, then private negotiations will lead to efficient outcomes. But private negotiations can lead to efficient outcomes even if property rights are not well defined or their assignments are not agreed to, and even if transactions costs are positive.

Ragesh K. Tangri, *Ending Patent Law's Willfulness Game*, 18 BERKELEY TECH. L.J. 1085, 1102 (2003) ("All of these rules presuppose that potential infringers actually read the patent disclosure. If they don't, and instead take their lawyers' advice and avoid patents in order to escape the taint of willfulness, the patent system's goal of disclosure is frustrated."). In such situations, the implementers are not even aware of the existence of relevant patents.

61. *See* Markman v. Westview Instruments, Inc., 517 U.S. 370, 388 (1996) (establishing claim construction as a matter for judges and giving birth to now–common "*Markman* hearings"); Peter S. Menell, Matthew D. Powers & Steven C. Carlson, *Patent Claim Construction: A Modern Synthesis and Structured Framework*, 25 BERKELEY TECH. L.J. 711, 814–18 (2010) (describing the conduct of *Markman* hearings).

62. *See* Edward F. Sherry & David J. Teece, *Royalties, Evolving Patent Rights, and the Value of Innovation*, 33 RES. POL'Y 179 (2004).

63. Mark A. Lemley & Carl Shapiro, *Probabilistic Patents*, 19 J. ECON. PERSP. 75 (2005).

By way of illustration, suppose that there is uncertainty about whether a given patent is valid and infringed by some product; suppose that the parties agree that, if the issue were litigated, there is only a 50% chance that the patent would be found valid and infringed. Suppose further that the parties would negotiate a 10% royalty if the patent were known to be valid and infringed. Given the uncertainty, a rational licensee would not pay the full 10% royalty given that there is only a 50% chance that the patent would be found valid and infringed if challenged. But the parties may be able to negotiate a license for the "untested" patent calling for a 5% royalty. In such a situation, both parties are better off than they would be without such a license; the result is efficient. That is true even though the patent is only "probabilistic."

As noted, a patent holder cannot as a practical matter unilaterally refuse to supply its technology to others who do not pay for it. This is because patents are published, exposing key elements of the invention to competitors, imitators, and implementers.[64] Accordingly, the patent holder must resort to costly and risky litigation to persuade a court or some other enforcement or regulatory agency to enforce its rights. This is unlike the supplier of a tangible input, which can refuse to deliver it unless and until paid. The essence of the situation is that patents are not self–enforcing. In the United States, only the federal courts (plus the International Trade Commission or imports) have the authority to block the sale of infringing products.[65]

The above observation implies that firms often take the calculated risk of being sued for infringement. In some case, they may knowingly infringe taking a "catch me if you can" attitude. In other cases, validity may be questionable and boundaries may be fuzzy. The proper moral, ethical, and legal approaches are to (a) negotiate all potentially necessary licenses in advance or (b) choose not to proceed with infringement of the patent. Both sides need to be reasonable and admit to some amount of ambiguity.

However, instead of widespread *underuse* as predicted in the anticommons literature, in many industries (notably the mobile phone industry), it is quite common for firms to take a "catch me if you can"

64. Patent rights apply even to "independent inventors" who developed the technology without reading the published patent. *See, e.g.*, Robert P. Merges, *A Few Kind Words for Absolute Infringement Liability in Patent Law*, 31 BERKELEY TECH. L.J. 1, 3–4 (2016) (explaining that patent law currently does not recognize an "independent invention" defense and thus may be characterized as imposing "absolute liability").

65. 19 U.S.C. § 1337 (2012) (granting the ITC authority to block importation of goods that infringe patents); Suprema, Inc. v. Int'l Trade Comm'n, 796 F.3d 1338, 1340 (Fed. Cir. 2015) (affirming broad ITC discretion to block infringing goods).

approach and launch and market products without negotiating licenses in advance.[66] Such "widespread infringement" or *overuse* means that patent holders, far from being adequately compensated or overcompensated for their innovations, run the risk of being undercompensated.[67] If an accused infringer merely has to pay what it would have paid had it negotiated for a license to untested patents if and when it is sued and found liable, then the infringer has an incentive to play "heads I win, tails I break even" game. This in turn implies that a damages award following a verdict of validity and infringement should reflect not the rates that would have been negotiated *ex ante* for an *untested* patent, but the rates appropriate for a proven–valid–and–infringed patent.

Unfortunately, courts too often award their estimates of "reasonable royalties," sometimes interpreted (conceptually incorrectly) as the rate that would have been agreed to *ex ante* for *untested* patents,[68] even after the patent holder has been forced to incur the risk and expense of litigation to prove validity and infringement.

Since the preconditions of the Coase Theorem (and in particular, the assumptions that transaction costs are zero and the requirement that property rights are well defined and their assignment agreed upon) frequently do not hold (in particular, patents are probabilistic), it is perhaps remarkable that technology development is not arrested. However, as a practical matter there are at least five reasons that Coasian type (private ordering) solutions nevertheless emerge. Quite simply, patent owners have reasons to go ahead and use and/or enter voluntary agreements that result in the licensed use of patents even when the Coasian conditions are not satisfied. They are: (i) as a practical matter, infringement is an option, in the sense that court injunctions are difficult to get post *eBay*,[69] and so

66. *See* Michael P. Akemann, John A. Blair & David J. Teece, *Patent Enforcement in an Uncertain World: Widespread Infringement and the Paradox of Value for Patented Technologies* (Tusher Ctr. for Mgmt. of Intellectual Capital, Working Paper No. 6, 2014), http://innovation-archives.berkeley.edu/businessinnovation/documents/Tusher-Center-Working-Paper-6.pdf.

67. *See id.*

68. The clearest example is when a court determines that there is an "established royalty" and awards that royalty as damages, when the licenses that serve as the basis for the "established royalty" were negotiated in the context where patent validity and infringement were not established (and may well have been disputed).

69. This applies with less force to the ITC's powers to enjoin infringing imports. *See* Daniel E. Valencia, *Appeals From the International Trade Commission: What Standing Requirement?*, 27 BERKELEY TECH. L.J. 1171, 1171 (2012) (describing the ITC's broad powers). These powers have not been impaired by the *eBay* decision, though some have suggested that the ITC's ability to exclude products should be limited along the lines of the

infringement often is not deterred. Moreover, unlicensed use is tempting if there is some chance that the patent owner will not find out or has other reasons not to sue; in such situations, the patent holder may acquiesce to the situation and enter into a license; (ii) major players often all have relevant patent portfolios, opening up the possibility of cross licensing;[70] (iii) in other cases, patent pools exist or can be created;[71] (iv) in yet other circumstances, "Mexican standoff" situations emerge where the parties tacitly agree that mutual unlicensed use of each other's patented technology is better than patent warfare;[72] finally, (v) there may be other points of contact, such as supply agreements or purchase agreements between the very parties that need licenses. If so, such factors can also facilitate licensing, or a "Mexican standoff" resolution, for fear that pursuing a patents infringement would sour the overall business relationship between the firms.

Hence, even if the assumptions of the Coase Theorem do not hold, private ordering arrangements frequently emerge, and government and judicial action is not required. Indeed, recent scholarly work around "patent thickets" in sewing machines,[73] automobiles,[74] and aircraft[75] have shown that early beliefs about mutually blocking patent situations were in fact

eBay four–factor test. *See, e.g.*, Natalie Flechsig, *Trade Secret Enforcement After* TianRui*: Fighting Misappropriation Through the ITC*, 28 BERKELEY TECH. L.J. 449, 479 (2013) (calling for the application of *eBay* to limit the ITC's exclusionary powers).

70. *See* Peter C. Grindley & David J. Teece, *Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics*, 39 CAL. MGMT. REV. 8, 9 (1997) ("Many managers now understand the use of licensing and cross-licensing as part of business strategy as well as the importance of a valuable patent portfolio.").

71. For a rigorous treatment of patent pools from leading scholars on the subject, see Robert P. Merges & Michael Mattioli, *Measuring the Costs and Benefits of Patent Pools*, 78 OHIO ST. L.J. 281 (2017).

72. *See* Egan & Teece, *supra* note 12, at 20; David Teece, Edward Sherry & Peter Grindley, *Patents and "Patent Wars" in Wireless Communications: An Economic Assessment*, 95 DIGIWORLD ECON. J. 85, 88 (2014).

73. Adam Mossoff, *The Rise and Fall of the First American Patent Thicket: The Sewing Machine War of the 1850s*, 53 ARIZ. L. REV. 165, 206 (2011) ("[T]he underlying assumption is that patent thickets are a relatively modern problem to which a public-ordering regulatory model is the best, if not only, solution. . . . [T]he Sewing Machine Combination confirms that voluntary, privately formed patent pools are not just theoretically possible, but have long occurred in the real world.").

74. John Howells & Ron Katznelson, *The Patent Troll Fables of the Automobile Industry*, IPWATCHDOG (June 30, 2016), http://www.ipwatchdog.com/2016/06/30/patent-troll-fables-automobile-industry/id=70468/.

75. John Howells & Ron Katznelson, *The Myth of Early Aviation Patent Holdup—How a Government Monopsony Commandeered Pioneer Airplane Patents*, 24 INDUS. & CORP. CHANGE 1, 2 (2015) (arguing that "many secondary sources that repeat the aircraft patent hold-up allegation" but claiming that primary sources show "there was . . . no patent hold-up or development suppression" as a matter of historical fact).

erroneous (or seriously overstated) fables. Put differently, Coasian solutions to the problems of social costs exist even when the Coasian assumptions do not hold.

The inevitable conclusion is that despite ambiguity around property rights, and despite transaction costs that are often nontrivial, private ordering still frequently works reasonably well. While a narrow reading of the prerequisites for the Coase Theorem would suggest that the conditions for eliminating the problem of social cost are unlikely to exist, other institutional and organizational factors and arrangements serve to render private ordering solutions robust enough to almost entirely resolve the anticommons problem.

The next Part discusses yet another mechanism that serves to soften, if not eliminate, anticommons fears in certain contexts that have received much attention in recent years—namely, the development of compatibility standards.

E. STANDARDS, STANDARD ESSENTIAL PATENTS, FRAND, AND THE "ANTICOMMONS"

There are other situations and associated arrangements, not discussed by Heller and Eisenberg and not listed above, that structurally serve to "solve" Heller and Eisenberg anticommons "problems" in relevant (though obviously not all) contexts. The situation in question involves standards setting and standards development activities that implicate complex products. These incorporate cutting–edge technologies, many of which are patented or patent–pending.

These situations appear to fit Heller and Eisenberg's "anticommons" dilemma situations. The standards development situation involves (a) fragmented ownership of numerous complementary inputs (in this case, patented technologies needed to practice a standard) and (b) implementers that need access to numerous, diversely owned inputs (standards essential patents or "SEPs") in order to make and sell commercially viable standards–compliant products.[76] As such, the situation is directly analogous to the Heller and Eisenberg biotechnology situation. However, there are well–recognized "solutions" not discussed by Heller and Eisenberg (or by Coase) that have evolved to help surmount the potential for a so–called "tragedy of the anticommons" in these situations.

76. Li, supra note 27; Jorge L. Contreras & Richard J. Gilbert, *A Unified Framework for RAND and Other Reasonable Royalties*, 30 BERKELEY TECH. L.J. 1451, 1454 (2015).

The situation can be illustrated by cellular phone development and manufacturing, for which there are hundreds of thousands of patents held by thousands of firms.[77] In many standards development contexts, including telecommunications standards, multiple firms own patents that can read on the proposed standards–compliant products.[78] In these situations, standards development organizations (SDOs) (such as the IEEE and ETSI) typically adopt policies specifying that they will not incorporate patented technology into a proposed standard unless owners of patents that are "essential" to practice the proposed standard commit to making licenses available to an unlimited number of implementers of the proposed standard on "reasonable and non–discriminatory" (RAND) or "fair, reasonable and non–discriminatory" (FRAND) terms and conditions.[79]

For many modern standards, there are tens of thousands of such SEPs and thus thousands of such FRAND commitments that are made, often quite routinely.[80] Indeed, many SEP holders make "blanket" commitments to making licenses available to whichever of their patents turn out to be essential to practice the standard on FRAND terms.[81]

FRAND licensing largely sweeps away the anticommons problem. Patent owners agree to make an unlimited number of licenses available (i.e., licensing is nonexclusive). They agree to do so on FRAND terms. This allows widespread use of SEPs. To be sure, the FRAND commitment system is not a panacea. In particular, rancorous disputes can and do arise

77. Mike Masnick, *There Are 250,000 Active Patents That Impact Smartphones; Representing One in Six Active Patents Today*, TECHDIRT (Oct 18, 2012, 8:28 AM), www.techdirt.com/articles/20121017/10480520734/there-are-250000-active-patents-that-impact-smartphones-representing-one-six-active-patents-today.shtml; Evan Engstrom, *So How Many Patents Are There in a Smartphone?*, ENGINE (Jan. 17, 2017), www.engine.is/news/category/so-how-many-patents-are-in-a-smartphone (noting that Bluetooth alone incorporates patents from 30,000 firms).

78. *See* Chia, *supra* note 35, at 210–12 (explaining the standard–setting process).

79. Contreras & Gilbert, *supra* note 76, at 1453–54.

80. Knut Blind & Tim Pohlmann, *Trends in the Interplay of IPR and Standards, FRAND Commitments and SEP Litigation*, LES NOUVELLES 177, 177 (Sept. 2013), http://www.iplytics.com/download/docs/articles/Blind_Pohlmann_2013_Trends%20In%20The%20Interplay%20Of%20IPR%20And%20Standards.pdf ("Not only the number of SEPs, currently approximately 10,000 active patents . . . but also the number of SEP holders, approximately 800 entities, has been increasing.").

81. Jay P. Kesan & Carol M. Hayes, *FRAND's Forever: Standards, Patent Transfers, and Licensing Commitments*, 89 IND. L.J. 231, 245 (2014) ("Thus, companies may have an incentive to not undertake expensive investigations of their own patent portfolios for the purpose of disclosing specific patents as potential SEPs. However, such companies may be more willing to make a blanket commitment to the SSO to license any SEPs on FRAND terms without identifying the SEPs individually.")

about whether proposed licensing terms are or are not consistent with a FRAND commitment.[82] Many of the recent major patent lawsuits over smartphones involve such disputes. But the courts are able to deal with such disputes, although how efficient they are at doing so is open to question. The fact that the system works reasonably well (even though not perfectly) suggests that the Heller and Eisenberg "underuse" conclusion is seriously flawed. And it seems somewhat incongruous to label disagreements over prices (royalty rates) as leading to a "tragedy."

F. EVIDENCE FROM BIOTECH AND MOBILE PHONES

Both the biotechnology and mobile phone industries are commonly held up as paradigm–examples of anticommons that produce underuse. Heller and Eisenberg's original article, for example, took biotechnology as its case study.[83] Similarly, "[a]n influential literature claims that standard setting in the smartphone industry creates monopoly power" that produces underuse.[84] This Section addresses both examples directly and shows that they do not support Heller and Eisenberg's anticommons thesis.

1. *Biotechnology*

As noted earlier, one can seriously question the conclusion by Heller and Eisenberg that there is a substantial amount of "underuse" of patented technology even in the biomedical research field. In many fields, firms are intentionally deciding not to conduct inquiries into patents potentially relevant to what they intend to do, for fear that, if they discover relevant patents but choose not to take licenses, they may be found liable for up–to–trebled damages for "willful infringement."[85] Many researchers can and do use technology without securing the potentially necessary licenses beforehand, often taking the position that they will deal with potential infringement lawsuits if and when they are sued, gambling that (1) the patent holder may not detect the claimed infringement, (2) the patent holder will not sue unless the researcher is successful in developing and marketing

82. Jorge L. Contreras, *Fixing FRAND: A Pseudo-Pool Approach to Standards-Based Patent Licensing*, 79 ANTITRUST L.J. 47, 62 ("[B]ecause FRAND commitments by themselves have proven to be vague and indeterminate, this protection can be largely illusory."); Jorge L. Contreras, *Why FRAND Commitments are Not (Usually) Contracts*, PATENTLY-O (Sept. 14, 2014), https://patentlyo.com/patent/2014/09/commitments-usually-contracts.html (discussing lawsuits over the requirements of FRAND agreements)

83. Though, as noted *supra* Part II, Heller and Eisenberg's article amounted to little more than anecdotal analysis and lacked rigorous empirical support.

84. Alexander Galetovic, Stephen Haber & Lew Zaretzki, *Is There an Anticommons Tragedy in the Smartphone Industry?*, 32 BERKELEY TECH. L.J. 1527, 1529 (2017).

85. *See supra* note 60.

a product, (3) patent holders will not incur the (substantial) cost and risk of litigation unless they believe that the expected damages award will exceed the cost of litigation, and (4) the asserted patents may be found invalid and/or not infringed.[86]

Empirical scholarship since the publication of Heller and Eisenberg's article challenges the notion of a pervasive "underuse" in biotech. For example, in a 2005 article in *Nature Biotechnology*, Ebersole, Guthrie, and Goldstein examine standards and patent pools in the field of "diagnostic genetics" and find that patent pools can significantly mitigate the risk of underuse while spurring innovation.[87] Similarly, in a chapter in a 2008 handbook on "Patent Law and Theory," Goldstein discusses how the patent pools and standards setting in the biotechnology field has enabled broad industry access to patented technologies.[88] Thus, at a minimum, the Heller–Eisenberg hypothesis of "underuse" arising from fragmented ownership of patent rights in the biotechnology field needs to be reconsidered in the light of this evidence, the Walsh et al. evidence cited earlier,89 as well as evidence of the formation of functioning patent pools and other potential patent pools, in at least one major biotechnology field.

The strongest possible case for underuse is that the small size of many startup biotech firms, plus the importance of intellectual property rights in the biotech field and risk aversion by venture capitalists, may potentially lead to a situation in which venture capitalists are unwilling to invest money in a new firm. However, this reluctance to invest can be overcome if the startup can demonstrate (a) a reasonable likelihood of success, (b) a

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86. *See supra* Section II.C.

87. Ted J. Ebersole, Marvin C. Guthrie & Jorge A. Goldstein, *Patent Pools and Standard Setting in Diagnostic Genetics*, 23 NATURE BIOTECHNOLOGY 937 (2005). They conclude: "Properly structured and implemented, diagnostic patent pools could integrate complementary technologies, reduce transaction costs and spur innovation." *Id.* at 937; *see also* Jeanne Clark et al., *Patent Pools: A Solution to the Problem of Access to Biotechnology Patents?*, 20 BIOTECHNOLOGY L. REP. 607, 615–18 & n.34 (2001) (describing how patent pools can produce biotech innovation and overcome anticommons problems).

88. Jorge A. Goldstein, *Biotechnology Patent Pools and Standards Setting*, *in* PATENT LAW AND THEORY: A HANDBOOK OF CONTEMPORARY RESEARCH 712, 714 (Toshiko Takenaka ed., 2005) ("[T]he use of carefully crafted patent pools is reasonably likely to make patents pertaining to the diagnosis of polymutationally correlated diseases available to the industry at reasonable royalties.").

89. Even Mark Lemley, a strong proponent of various strains of the anticommons theory, appears to recognize the significance of the Walsh et al. study for university research. *See* Mark A. Lemley, *Ignoring Patents*, 2008 MICH. ST. L. REV. 19, 21 (2008). ("John Walsh's study suggests that threats of patent infringement are not in fact responsible for deterring much, if any, research.").

thought–out plan to protect the firm's output from competition by patent protection or otherwise, and (c) a low likelihood of credible threats that the firm will be sued (successfully or not) by others for patent infringement and have to incur the cost and distraction of defending itself against such threats.

2. Mobile Phones

Similar evidence exists with respect to mobile phones, and electronics more generally. Despite the fact that implementers need access to all valid–and–infringed SEPs[90] in order to make and sell standards–compliant products, it is widely recognized that implementers benefit when SEP holders have made FRAND commitments. In the digital electronics industry, this requirement is common among standards setting and standards development organizations. Partly as a result, there is no obvious problem of impaired innovation. Indeed, studies by Keith Mallinson[91] and Galetovic, Haber, and Levine[92] speak to rapid innovation. FRAND commitments reduce if not eliminate the prospect that implementers will not be able to obtain the necessary licenses, at least as long as they are willing to pay the FRAND royalties.

That is, the "tragedy of the anticommons"—underuse of potentially relevant IP—is virtually eliminated with respect to SEPs by the presence of FRAND commitments. As noted in Section II.E, there are still sometimes disagreements between parties as to whether particular royalty rates are or are not "reasonable." The courts have to resolve such disputes, and in a manner that helps sustain innovation and prosperity.

The mobile telecommunications sector of the economy is heavily dependent on standards. The thesis of "underuse" of patented technology due to fragmented ownership of patents is difficult to credit in this sector, given its explosive growth and the entry of scores of newcomers. If anything, the problem is that widespread infringement is common, and innovators are not being adequately compensated for the use by others of their patented technology.

90. Not all patents that have been "declared" as essential to some standard are in fact essential. A patent that is invalid and/or not infringed cannot block others' use of the claimed technology (though of course it may be expensive for both parties to determine whether an asserted patent is or is not valid and infringed).

91. Keith Mallinson, *Don't Fix What Isn't Broken: The Extraordinary Record of Innovation and Success in the Cellular Industry Under Existing Licensing Practices*, 23 GEO. MASON L. REV. 967 (2016).

92. Alexander Galetovic, Stephen Haber & Ross Levine, *An Empirical Examination of Patent Holdup*, 11 J. COMPETITION L. & ECON. 549 (2015).

III. THE "TRAGEDY OF THE ANTICOMMONS" FALLACY

In this Part, the various threads discussed above are pulled together to deliver a major indictment of the anticommons thesis on "underuse"; it all but turns the Heller and Eisenberg thesis on its head and argues that patent holders are systematically *undercompensated* for their innovations.

The analysis above summarizes theory and evidence surrounding Heller and Eisenberg's tacit (but false) conclusion that, without judicial or policy interventions, there is inefficient underuse of patented technology. Their paradigm is wrong with respect not only to biotech (as Eisenberg now seems to recognize), but also to standards essential patents where patent owners make FRAND commitments. Their tacit assumption was that, without agreement in advance, risk–averse potential implementers will err on the side of caution and avoid using technology claimed by others without first coming to an agreement. That assumption is often not true in the context of patented technology.

Unlike suppliers of tangible goods who will refuse to deliver unless they are assured they will get paid, patent holders cannot physically withhold their technology from others. Instead, they must resort to costly and risky legal proceedings to enforce their rights. Put another way, patent rights are not self–enforcing; patent holders cannot resort to the sorts of "self–help" mechanisms available to suppliers of tangible goods (like withholding delivery). Firms can (and routinely do) use patented technology whose ownership is claimed (rightly or wrongly) by others without paying for it. Many firms routinely ignore (and are often entirely unaware of the existence of) relevant patents.[93]

In my view, the real "tragedy" to be concerned about is not that business enterprises are being deterred from using patented technology, but that innovators are not getting paid sufficiently because of unlicensed use. This is troubling from a public policy and social welfare perspective. There are many contexts (e.g., mobile phones) where some firms use intellectual property owned by others without paying for it (indeed, in some contexts widespread infringement routinely occurs). Even Eisenberg subsequently recognized this in the biotechnology field but did not see this as a problem, let alone a "tragedy."[94] The knock–on consequence is that firms will

93. Lemley, *supra* note 89, at 21 ("[B]oth researchers and companies in component industries simply ignore patents. Virtually everyone does it. They do it at all stages of endeavor. Companies and lawyers tell engineers not to read patents in starting their research, lest their knowledge of the patent disadvantage the company by making it a willful infringer.").

94. *See* Eisenberg, *supra* note 20.

underinvest in inventive activities because of underpayment that occurs.[95] This denies society access to new technology that would result from higher levels of investment in creative activities.

It is certainly true that risk–averse firms can be deterred from using technology (research tool or otherwise) claimed by others because of the fear of being falsely accused of infringement when there is no actual infringement. But if the implementer goes ahead and uses it without paying (the more common circumstance), then it is not so much that society's problem is not so underused as it is uncompensated overuse. In short, there is usually underpayment, not overpayment; uncompensated overuse, not underuse.

As noted, Heller and Eisenberg's fear of economic inefficiency arising from underuse does not appear to be significant either in biotech or in mobile phones. I am not aware of any evidence of "holdup."[96] This should not be surprising when one realizes patent owners cannot unilaterally deny others access to its technology; only a court can do that.

In the telecommunications field, firms often make and sell standards–compliant products without taking licenses under all of the claimed SEPs and without paying royalties (at least immediately) to many, and perhaps most, patent holders. Thus, contrary to the Heller and Eisenberg "underuse" theory, what one frequently sees is a situation of contemporaneously uncompensated use, often amounting to a situation of widespread infringement, implying that patent holders whose patented technology is being used are being currently undercompensated. The fact that firms are using others' patented technology without (currently) paying for it suggests that, if anything, there is overuse, not the underuse predicted by the proponents of anticommons theory.

The above reasoning is correct as far as it goes. But it disregards the fact that the infringer may be ordered to pay damages for its unlicensed use at some point in the future, should the patent holder prevail on the issues of liability and damages. If the court sets the damages level correctly and also requires infringers to pay prejudgment interest at the economically appropriate rate (a dubious assumption, to be discussed further below), the

95. Vincenzo Denicolò, *Do Patents Over-Compensate Innovators?*, 22 ECON. POL'Y 679, 703 (2007) (conducting empirical analysis of R&D return rates to conclude that insufficient patent protection for innovations will result in "under-compensation" that decreases initial investment)

96 Alexander Galetovic, Stephen Haber & Ross Levine, *No Empirical Evidence that Standard Essential Patents Hold-Up Innovation*, IPWATCHDOG (May 4, 2015), http://www.ipwatchdog.com/2015/05/04/no-empirical-evidence-that-standard-essential-patents-hold-up-innovation/id=57424/; Galetovic, Haber & Levine, *supra* note 92.

result is that compensation will not be eliminated entirely, but only delayed during the pendency of the litigation. Of course, should the patent holder not prevail on both validity and infringement, the court will award nothing in the way of damages. Whether the overall level will be over– or underuse, and whether patent holders are over– or undercompensated for others' use of their patented technologies, depends on the expected level of damages and prejudgment interest the infringer expects to ultimately be required to pay. There is simply no reason to expect that Heller and Eisenberg's conclusion that the mere existence of fragmented patent rights, the existence of an anticommons, will result in "underuse" holds once these factors are considered.

Whether undercompensation will persist in the face of finding an infringement depends on how the court sets damages following a verdict of validity and infringement. If the infringer is only ordered to pay the same level of royalties that it could have negotiated *ex ante*, prior to a finding of validity and infringement, then the infringer gets to play a "heads I win, tails I break even" game, which encourages infringement and results in overuse and undercompensation. If, however, following a verdict in the patent holder's favor, the infringer is required to pay a royalty rate appropriate for a proven–valid–and–infringed patent, rather than the (discounted) rate that it could have negotiated *ex ante* for what might be termed an "untested" patent—one for which the issues of validity and infringement have not been litigated, and which may be seriously disputed—then appropriate compensation is at most delayed, rather than being eliminated entirely.

A simple numerical example might help to illustrate the point. Suppose that everyone agreed that the rate for a patent, should it be shown valid and infringed, would be 10%. Suppose further that the patent holder and the potential licensee agree that there is only a 50% chance that the patent, if litigated, would be found valid and infringed. Faced with that uncertainty, a rational licensee would not be willing to pay the full 10% royalty appropriate for a valid–and–infringed patent for a license *ex ante*, before the patent is litigated. The parties might agree to a license calling for the licensee to pay royalties of 5%, the 10% rate for a proven–valid–and–infringed patent times the 50% probability that the patent, if litigated, would be found valid and infringed. The patent holder may well enter into a significant number of such *ex ante* licenses for an untested patent with numerous potential licensees. Indeed, the negotiated rate of 5% may come to be an "established" royalty.

If the patent holder is forced to litigate its patent, and it prevails, then it should be awarded the 10% royalty rate, which (by our assumption) is appropriate for a proven–valid–and–infringed patent, not the lower "established" rate of 5% negotiated for the "untested" patent.

If the court were to mistakenly award damages at the discounted 5% established rate instead of the economically appropriate 10% rate as damages following a verdict in the patent holder's favor, then the infringer would have little or no economic incentive (other than avoiding litigation costs) by taking a license; litigating is a "heads I win, tails I break even" strategy. Unfortunately, in our experience some courts argue that the accused infringer should be entitled to test the patent holder's claims of validity and infringement without suffering a "penalty" for unsuccessfully doing so. Other courts take existing licenses of 5% as evidence that court–awarded damages should likewise be 5%, because of the claim that the existence of numerous licenses demonstrates an "established royalty" that purportedly serves as a cap on damages.

The issue of the award of prejudgment interest was flagged earlier. If the defendant is only ordered to pay back royalties without interest (or at an inappropriately low rate of interest), it would again have an economic incentive to avoid taking a license, as it could avoid paying royalties now and only have to pay them in the future, gaining from the ability to use the royalties in the meantime. An award of prejudgment interest at the economically correct amount will eliminate this incentive.

Patent courts typically award prejudgment interest, but they have a significant degree of discretion in selecting the interest rate used. The economically appropriate rate would reflect both the opportunity cost faced by the patent holder by not having the money available earlier[97] and the fact that the patent holder was in effect compelled to make what can be thought of as something akin to a "forced loan" of the unpaid royalties to the infringer.[98] Unfortunately, many courts exercise their discretion to award prejudgment interest at a much lower rate, often the risk–free rate (the T–bill rate), the inflation rate, the prime rate, the federal rate on *post*–judgment interest (which is set by statute at the T–bill rate), or some rate tied to the rate awarded by some selected state court (often set statutorily, and sometimes calculated as simple interest rather than using the economically correct compound interest approach), such as the patent holder's state of

97. This opportunity cost should generally be measured by the patent holder's weighted average cost of capital (WACC).

98. The opportunity cost of this forced loan should be measured by the defendant's adjusted debt rate (adjusted for the differences between an ordinary loan and a litigation claim, which are substantial).

incorporation or the state in which the trial is held.[99] If an economically inappropriately low rate of prejudgment interest is expected to be awarded, again the infringer has an incentive to delay payment by not taking a license, but paying damages–plus–prejudgment–interest instead.

One potential limitation on the above discussion is the real possibility that the courts may make either what statisticians call a "Type I" or "false positive" error on liability and/or damages—finding the accused infringer liable when it should not be found liable, and/or awarding excessive damages—or what statisticians call a "Type II" or "false negative" error—finding the accused infringer not liable when it should have been found liable, and/or awarding insufficient damages. Unfortunately, I know of no data source available to measure the likelihood of either Type I or Type II errors for either liability and damages issues,[100] though I expect that the error rates are not inconsiderable, especially for damages, as courts are notoriously bad at setting prices.

IV. PATENT DAMAGES AND THE AMPLIFIED SOCIAL WELFARE LOSSES WITH GENERAL–PURPOSE TECHNOLOGIES

In the discussion above, this Article showed that in invention–rich environments, unpaid use was likely the bigger problem, and that as a consequence of the reduced rewards for innovation from free riding, society would not receive the level of invention that it would otherwise enjoy. Interestingly—and especially in the patent–rich environment Heller and Eisenberg were examining—under–compensation is likely to be amplified further when the environment is not only patent rich, but when those patents cover enabling or general–purpose technologies (GPTs) because of the uncaptured social value generated by such technologies.[101] Accordingly, this Part reviews the literature on social returns to innovation and then discuss the special circumstance of GPTs.

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99. *See, e.g.*, Brunswick Corp. v. United States, 36 Fed. Cl. 204, 219 (1996), *aff'd*, 152 F.3d 946 (Fed. Cir. 1998) (rejecting WACC as a measure based on the "strong judicial policy in just compensation cases favoring the establishment of uniform interest rates in order to avoid discrimination among litigants"); Hynix Semiconductor Inc. v. Rambus Inc., No. CV-00-20905 RMW, 2006 WL 2522506, at *1 (N.D. Cal. Aug. 30, 2006) (rejecting WACC as "too speculative" a measure for damages).

100. There are numerous studies of win rate data, but they do not measure the probability of either Type I or Type II errors.

101. For consistency and simplicity, this Article uses the moniker "general–purpose technologies," though such innovations are also sometimes termed "enabling" technologies.

A. SOCIAL RETURN TO INVESTMENT IN R&D COMPARED TO PRIVATE RETURNS

It is well recognized in the economics literature that society underinvests in R&D and innovation because of positive externalities (spillovers) that go unrewarded. There is often a sizable gap between the private return to successful innovators and the return of such innovations to society as a whole, after accounting for spillovers. Spillovers occur because (1) an innovating firm is not able to charge the full value to consumers of its goods due to imperfect price discrimination, weak appropriability, or competition; and (2) some of the knowledge generated by the implementation of an innovation (e.g., the appearance and function set of the iPhone) leaks to rivals without adequate—or any—intellectual property protection.[102]

A number of efforts have been made to quantify the gap between social returns and private returns. Statistical studies by different researchers using different methods over several decades have identified a consistent disparity between social returns to investment in innovation and the private return to the innovator. While the different estimates vary, they are all fairly large, suggesting that the innovators are underpaid to a significant degree for the use that occurs.

One common approach is to analyze the returns to single innovations, typically using estimates of consumer surplus as a measure of social benefit. The earliest study of this type was done by Zvi Griliches, who estimated the annualized social rate of return to public and private R&D on hybrid corn since 1910 as lying between 35% and 40%.[103] The literature reviewed by Hall, Mairesse, and Mohnen found social returns to agricultural innovation as high as 100%.[104] Mansfield et al. computed the private and social rates of return for seventeen industrial product and process innovations.[105] Across the seventeen innovations, they obtained a median social return of 56%

102. Zvi Griliches, *The Search for R&D Spillovers*, *in* R&D AND PRODUCTIVITY: THE ECONOMETRIC EVIDENCE 251 (Zvi Griliches ed., 1998).

103. Zvi Griliches, *Research Costs and Social Returns: Hybrid Corn and Related Innovations*, 66 J. POL. ECON. 419, 425 (1958) ("The internal rate of return on hybrid-corn research expenditures is between 35 and 40 per cent.").

104. Bronwyn H. Hall, Jacques Mairesse, & Pierre Mohnen, *Measuring the Returns of R&D*, *in* 2 HANDBOOK OF THE ECONOMICS OF INNOVATION 1033, 1071 (Bronwyn H. Hall & Nathan Rosenberg eds., 2010) ("[W]hen the estimates are obtained separately for each industry, they range from close to zero to a full 100% (or even larger in a few cases).").

105. Edwin Mansfield et al., *Social and Private Returns from Industrial Innovation*, 91 Q.J. ECON. 221, 234 (1977) ("The median estimated social rate of return is about 56 percent. . . . The median private rate of return (before taxes) was about 25 percent.").

against a median private (firm–level) rate of about 25%.[106] A similar study by Tewksbury et al. derived a median social rate of return of 99% against a private rate of return of 27%.[107] Manuel Trajtenberg estimated the benefits of CT scanners during their first decade in use and found that they were 270% greater than the R&D that had been spent on them. [108] Teece et al. analyzed Pilkington PLC's 1952 invention of the float process that revolutionized glass making, which Pilkington chose to license to other firms in markets outside the United Kingdom.[109] The private rate of return to Pilkington for its portfolio of patents and trade secrets was estimated at about 21%, versus a global social rate of return from 29% to 62%, depending on the measure used.[110]

A different type of study uses industry–level data on R&D and productivity, comparing the within–industry return on R&D to the nationwide increase in output that is found to be statistically attributable to it. Table 1 summarizes some of these studies. The private (within–industry) return to R&D includes spillovers that accrue to non–innovating firms within the same industry as the innovator, so the net spillover (social minus private return) in these estimates is lower than its true value.[111]

A more recent study by Bloom et al. estimated firm–level private and social returns to R&D using data from 1980 to 2001 for more than 700 publicly listed companies that had been granted at least one patent. They constructed a model that accounts for (1) the likelihood that a given firm benefits from spillovers of R&D performed by other firms and (2) the likelihood that some of the firm's business will be taken away by other firms

106. *Id.*

107. J. G. Tewksbury, M.S. Crandall & W.E. Crane, *Measuring the Societal Benefits of Innovation*, 209 SCIENCE 658, 659 tbl. 1 (1980).

108. Manuel Trajtenberg, *The Welfare Analysis of Product Innovations, with an Application to Computed Tomography Scanners*, 97 J. POL. ECON. 444, 472 (1989) ("I obtain a capitalized benefit/cost ratio of 270 percent (this is the average between two alternative specifications, one using R & D by U.S. firms only, the other including R & D by foreign firms as well).").

109. David J. Teece, Peter C. Grindley & Edward F. Sherry, *The Glass Industry and the Pilkington Float Process*, *in* MANAGING INTELLECTUAL CAPITAL: ORGANIZATIONAL, STRATEGIC, AND POLICY DIMENSIONS 225 (David J. Teece ed., 2002).

110. *Id.* at 244.

111. There are contradictory factors that would make the estimates both larger and smaller than the actual underlying value. On the one hand, they are partial equilibrium estimates that probably overstate the difference that would be found if a comparison were made to a counterfactual in which the innovating firms had actually charged more for the use of their innovations. On the other hand, they use industry–level data that mixes all types of R&D together, which might understate the value of the private–social difference that exists for the subset of licensable innovations.

innovating in similar product markets. Using multiple measures, they found that social returns, which ranged from 55% to 74%, were about twice as large as private returns, estimated to be from 21% to 40%.[112] For the half of the sample with the largest firms, they found that spillover social benefits were as much as three times larger than private returns.

While all net social return estimates are based on imperfect data, the general pattern is consistent across industries, years, and geographies: an innovator will receive only a tiny fraction of the social returns from innovation, and the gap is likely to be greater the more widely applicable the innovation. For instance, in the case of the float glass process, Teece et al. estimated that Pilkington (the innovator and owner of the pioneering patents and trade secrets) received only 4.2% of the benefits measured in terms of consumer surplus.[113] The well–documented presence of social returns greater than private returns—whatever the actual gap may be in a particular case—leads to the conclusion that private firms, absent other incentives, will make insufficient investment in innovation when considered from the perspective of society as a whole.

112. Nicholas Bloom, Mark Schankerman & John Van Reenen, *Identifying Technology Spillovers and Product Market Rivalry*, 81 ECONOMETRICA 1347, 1384 (2013).

113. Teece, Grindley & Sherry, *supra* note 109.

Table 1: Selected Industry–Level Estimates of Private and Social Rates to Return to Investment in R&D

Study	Sample (Location, Size, Time Period)	Within–Industry Return	Return in Other Industries
Griliches and Lichtenberg (1984)[114]	United States 193 industries 1959–78	11% to 31%	50% to 90%
Goto and Suzuki (1989)[115]	Japan 50 industries 1978–83	26%	80%
Bernstein and Nadiri (1989)[116]	United States 4 industries 1965–78	7 %	9% to 13%
Bernstein (1998)[117]	Canada 11 industries 1962–89	12.8%	19% to 145%
Bernstein (1998)[118]	United States 11 industries 1962–89	16.4%	28% to 167%
Griffith, Redding, and Van Reenen (2004)[119]	12 OECD countries 12 industries 1974–90	47% to 67%	57% to 105%

114. Zvi Griliches & Frank Lichtenberg, *Interindustry Technology Flows and Productivity Growth: A Reexamination*, 66 REV. ECON. & STAT. 324 (1984).

115. Akira Goto & Kazuyuki Suzuki, *R&D Capital, Rate of Return on R&D Investment and Spillover of R&D in Japanese Manufacturing Industries*, 71 REV. ECON. & STAT. 555 (1989).

116. Jeffrey I. Bernstein & M. Ishaq Nadiri, *Research and Development and Intra-Industry Spillovers: An Empirical Application of Dynamic Duality*, 56 REV. ECON. STUD. 249 (1989).

117. Jeffrey I. Bernstein, *Factor Intensities, Rates of Return, and International Spillovers: The Case of Canadian and U.S. Industries*, 49/50 ANNALES D'ÉCONOMIE ET DE STATISTIQUE 541 (1998).

118. *Id.*

119. Rachel Griffith, Stephen Redding & John Van Reenen, *Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Manufacturing Industries*, 86 REV. ECON. & STAT. 883 (2004).

B. SOCIAL RETURNS TO GPT[120]

General Purpose Technologies (GPTs) are those technologies which (a) are widely used, (b) are capable of ongoing technical improvement, and (c) enable complementary innovation in application sectors.[121] Such technologies not only have impacts on many sectors of the economy but also improve rapidly and spawn further downstream innovations. Upstream GPT innovation benefits downstream complementary innovation. For example, the introduction of electric motors allowed the redesign of factories.[122] According to Bresnahan and Trajtenberg, semiconductors are the dominant GPTs of our time.[123] Other examples are nanotechnology, lasers, and 2G, 3G, 4G, and 5G wireless communications standards technologies. These technologies have had (or will have) economy–wide effects and end up reshaping the economy and supporting (if not spawning) downstream innovation.

Although anticommons situations—the presence of fragmented rights owned by multiple entities—arise in many different contexts, concerns are especially significant in the context of GPTs, which today are seldom "invented" by a single innovator but rather developed and contributed to standards organizations or other alliances.

The business model (appropriability) problems alluded to above are amplified in the presence of GPTs because they are, by definition, relevant to multiple (downstream) applications. In consequence of their wide–ranging downstream applicability, the positive externalities of GPTs will likely be far larger than for single–industry innovations. With private returns so much lower than the society–wide benefit, firms are less likely

120. For definitions and further elaborations of these concepts, see David J. Teece, *Enabling Technologies*, *in* THE PALGRAVE ENCYCLOPEDIA OF STRATEGIC MANAGEMENT (Mie Augier & David J. Teece eds., 2016 ed.), and Alfonso Gambardella & Marco Giarratana, *General-Purpose Technology*, *in* THE PALGRAVE ENCYCLOPEDIA OF STRATEGIC MANAGEMENT (Mie Augier & David J. Teece eds., 2016 ed.)

121. Timothy F. Bresnahan, *Generality, Recombination, and Reuse*, *in* THE ROLE AND DIRECTION OF INVENTIVE ACTIVITY REVISED 611 (Josh Lerner & Scott Stern eds., 2012).

122. NATHAN ROSENBERG, INSIDE THE BLACK BOX TECHNOLOGY & ECONOMICS 77 (1982) ("Consider the case of electricity. . . . The social payoff to electricity would have to include . . . the benefits flowing from the new-found freedom to redesign factories with a far more flexible power source than was previously available under the regime of the steam engine.").

123. Timothy F. Bresnahan & M. Trajtenberg, *General Purpose Technologies: "Engines of Growth"?*, 65 J. ECONOMETRICS 83, 84 (1995) (comparing semiconductors to other "key technologies in the process of growth, such as the steam engine, the factory system, [and] electricity . . . .").

(than is socially optimal) to pursue investment in this type of generally applicable R&D, despite its potentially large impact on economic growth.

Furthermore, the commercialization of GPTs depends on the coordination of multiple entities. Because one cannot identify the recombinant possibilities of GPTs ex ante, firms cannot solve the bargaining problem early (i.e., downstream implementers will not pay the GPT innovators ahead of time).[124] They pay later, if at all. This is another reason why the level of investment in GPT will tend to be too low.

Social rates of return will be much greater than private rates of return for GPTs because of (a) complementarities and externalities due to the GPT triggering and enabling downstream innovation and also (b) horizontal complementarities and externalities.[125] Such vertical externalities magnify and help propagate the effects of GPT innovation. The downstream sectors are the application sectors. The rents earned downstream increase with the "quality" of the GPT.[126]

GPTs create the need for cooperation and coordination. As Bresnahan and Trajtenberg note, if the relationship between the GPT and its users is limited to arm's length market transaction, innovation will be "too little, too late" in both the GPT and the application sector.[127] The GPT and various applications can be thought of as strategic complements. These innovation complementarities help explain why social returns are greater than private returns. There are two fundamental externalities at work: (1) vertical, linking the upstream and downstream innovators, and (2) horizontal, linking the interests of companies in different areas. Firms upstream and downstream have linked payoffs: the upstream firm will only innovate efficiently if a mechanism allows it to appropriate an efficient fraction of the downstream returns.[128]

The rate of improvement in GPT depends on the number of applications and implementations. An externality therefore arises horizontally, since more applications and implementations should hasten the advance of the

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124. *See* Benjamin Jones, *Comment on Generality, Recombination, and Reuse*, in THE RATE AND DIRECTION OF INVENTIVE ACTIVITY REVISITED 656, 658 (Josh Lerner & Scott Stern eds., 2012).

125. RICHARD G. LIPSEY, KENNETH I. CARLAW & CLIFFORT BEKAR, ECONOMIC TRANSFORMATIONS: GENERAL PURPOSE TECHNOLOGIES AND LONG-TERM ECONOMIC GROWTH 442 & n.7 (2005).

126. Jones, *supra* note 124, at 658–59.

127. Bresnahan & Trajtenberg, *supra* note 123, at 86.

128. Bresnahan and Trajtenberg call this the "bilateral moral hazard problem." *Id.* at 94.

GPT, assuming that each application/implementation is contributing to the profit stream of the GPT developer.

With GPT and with implementers, there is benefit from increasing cooperation. Each implementer would like to see other implementers advancing their technology and paying the GPT to advance the upstream technology. Imperfect technological forecasting makes this difficult.[129] However, it is clear that horizontal and vertical interdependencies exist with GPTs; the viability of one level depends on the viability of the other, and vice versa.

One must consider, of course, that downstream technology licensees (implementers) might also be innovators. The higher royalties they might pay for (upstream) technology could conceivably dampen their own incentives to innovate. However, downstream implementers often have a plethora of business models to extract rents from their product (feature) innovation. The upstream firms, particularly if their technology is incorporated into a standard, often have no such luxury because of their FRAND commitments. If one is contractually committed to non–exclusive licensing, the ability to extract profits is generally weak, as explained below.

V. THE LIMITATIONS OF LICENSING AS A VALUE CAPTURE (BUSINESS) MODEL FOR GPT TECHNOLOGIES

The Heller and Eisenberg fable and concomitant concern about "royalty stacking" are factors that have led some scholars and some courts to proceed to gut royalties for SEPs for fear that they might be too high and might slow or otherwise impair technological adoption. However, the more worrisome and far more serious problem is the prospect of undercompensation to the patent owner. This is especially serious when technologies exhibit GPT characteristics.

As a general rule, undercompensation in the market is likely when economic realities are such that inventors are confined for one reason or using licensing as the principal tools (or business model) to capture value. As Nobel Laureate economist Kenneth Arrow remarked a half a century ago:

> Patent royalties are generally so low that the profits from exploiting one's own invention are not appreciably greater than

129. *See* David J. Teece, *Foreward to the Second Edition* of GEORGE RICHARDSON, INFORMATION AND INVESTMENT: A STUDY IN THE WORKING OF THE COMPETITIVE ECONOMY v, vii (1997).

> those derived from the use of others' knowledge. It really calls for some explanation, why the firm that has developed the knowledge cannot demand a greater share of the resulting profits.[130]

Fifty years later, it seems he had the same quandary, noting that:

> It is generally accepted that the main source of profits to the innovator are those derived from temporary monopoly. Why is it that royalties are not an equivalent source of revenues? In simple theory, the two should be equivalent.[131]

The enigma Arrow is grappling with is due in large measure to the fact that patents are not self–enforcing and licensing is not a high–powered instrument for capturing value from innovation, particularly when a technology is so general that it impacts scores of application areas, and possibly even industries. However, it may be the only model certain companies are able to implement. As noted above, GPTs generate positive "spillovers," vertically and horizontally. The obverse of spillovers is that the patent owner is yielding most of the value created with the license. As noted above, Pilkington's licensing program for float glass, considered a great success by most analysts, captured only a single–digit percentage of the social surplus. Implementers (in the Pilkington case, manufacturers) and consumers captured the lions share.

The business model that would in theory likely yield a higher return for the patent owner is vertical integration (i.e., own use of the technology and the sale of products in which the technology is embedded, not just the sale (licensing) of naked patent rights). This logic has been laid out in some of my earlier articles.[132] When licensing is required, strategic alternatives for the inventor are denied, and the owners of complementary assets and/or implementers usually capture most of the available profits.

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130. Kenneth J. Arrow, *Comment on The Origins of the Basic Inventions Underlying Du Pont's Major Product and Process Innovations, 1920 to 1950*, *in* THE RATE AND THE DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 353, 355 (Richard R. Nelson ed., 1962).

131. Kenneth J. Arrow, *The Economics of Inventive Activity Over Fifty Years*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY REVISITED 43, 47 (Josh Lerner & Scott Stern eds., 2012).

132. *See, e.g.*, David J. Teece, *Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy*, 15 RES. POL'Y 285 (1986); David J. Teece, *Reflections on "Profiting from Innovation"*, 35 RES. POL'Y 1131 (2006); David J. Teece, *Profiting from Innovation in the Digital Economy* (Tusher Cent. for Mgmt. of Intellectual Capital, Working Paper No. 16, 2016), http://businessinnovation.berkeley.edu/wp-content/uploads/2014/07/Tusher-Center-Working-Paper-No.-16.pdf .

As a practical matter, not all externalities in a market can be corrected. Notwithstanding, public policy shouldn't amplify distortions but should try to correct them. Accordingly, it is especially important that the courts, in adjudicating royalty rates and reasonable royalty damages, do what is possible within the law to award damages that err on the side of being privately generous, recognizing that being privately generous almost always implies being socially generous because of the positive externalities (spillovers) that innovation delivers, especially when GPTs are implicated.[133] Such awards will still likely be insufficient to correct the undercompensation and underinvestment problem, but go in the right direction. Courts should not be tricked by fallacious anticommons arguments into thinking that patents should be devalued because there are too many patents that the downstream use of the implementer might have to pay for. This is true for all technology, and is especially true for GPTs.

VI. CONCLUSION

Heller and Eisenberg focused on how patent thickets might block downstream innovation, not through "hold up" but through the sheer complexity of assembling the required (intellectual) property rights when they are diffusively owned. In this Article, the fact that this predicament might occur very occasionally is not disputed; but the notion that there is a systematic bias toward underuse (and concomitant overpayment) is rejected. The real property context situation fails to take into account several aspects of the manner in which patent rights differ from (real) property rights. The one most relevant here is that patents do not self–enforce (i.e., there is no private mechanism to exclude). Put simply, patent owners cannot take the problem of infringement into their own hands. They need courts to issue injunctions, which courts are reluctant to do, especially after *eBay*. Moreover, courts seem reluctant to grant damages that recognize the concept of the "infringer's royalty."

The absence of the ability to easily or credibly threaten to exclude infringers (especially difficult today when FRAND commitments have been made) renders Heller and Eisenberg's anticommons thesis barren if not misleading with respect to its ability to yield useful policy or judicial insights. Public policy problems are compounded when the courts don't appreciate the infringer's royalty concept and related issues (such as setting prejudgment interest at economically correct levels). When the legal

133. This is especially significant because licensees treat royalty payments as a private cost, whereas from a societal perspective they are largely a transfer payment from the licensee to the licensor.

standards do not reflect economic realities, infringement—rather than licensing—becomes the "solution" to the anticommons issues. Clearly, it is a very poor solution because it guts the incentive to invest in R&D and to innovate, compounding existing underinvestment problems.

Eisenberg seem to have subsequently recognized "unauthorized use" as a "solution." She did not seem to be troubled by that outcome and the investment distortions it generates. Unauthorized use (coupled with inadequate enforcement and damages that are too low) diminishes the chance that society will get the level of innovation it actually wants. It also undermines the whole intellectual property system.

Put differently, the real problem is likely precisely the opposite of the one that Heller and Eisenberg initially identified. The tragedy, if there is one, is underpayment for technologies that have high social returns, resulting in underinvestment in R&D and lower innovation and growth than society desires. Such undercompensation and underinvestment is a near certainty in circumstances where the patent owners have developed general–purpose technologies. The nature of the real "tragedy" is that society does not get what it is in fact willing to fund. The tragedy of widespread infringement and concomitant underinvestment in the generation of social beneficial technologies was not flagged by either Heller and Eisenberg or subsequent scholars, leaving multiple tragedies for the reader to ponder.