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The Value of the Standard

Tom Cotter

Norman Siebrasse

Article

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Norman V. Siebrasse[†] **& Thomas F. Cotter**[††]

† Professor of Law, University of New Brunswick Faculty of Law.

†† Briggs and Morgan Professor of Law, University of Minnesota Law School. We thank, for their comments and criticism, participants at the American Law and Economics Association's 2016 Annual Meeting at Harvard Law School; Tilburg Law & Economics Center's Conference on "Competition, Standardization, and Innovation"; IEEE's 9th International Conference on Standardization and Innovation in Information Technology; and conferences held at the University of Kansas, the University of Toronto, Kyushu University, and the Research Institute of Economy, Trade and Industry (Tokyo, Japan). Special thanks to Reiko Aoki, Rudi Bekkers, Sadao Nagaoka, Pierre Régibeau, and Masabumi Suzuki; the University of Minnesota Law School, for a summer research grant; and Geneva McSheffery for research assistance. Any errors that remain are ours.

INTRODUCTION

Standard-setting organizations (SSOs), such as the Institute of Electrical and Electronics Engineers (IEEE) and the European Telecommunications Standards Institute (ETSI), often encourages or requires members to disclose any patents that might read on a standard under consideration, to "declare" any patents that may be essential to that standard, and to commit to license those patents on "reasonable and nondiscriminatory" (RAND) or "fair, reasonable, and nondiscriminatory" (FRAND) terms.[1] SSOs themselves, however, typically do not define what a FRAND royalty for any given standard-essential patent (SEP) would be,[2] and when negotiations break down litigants increasingly are calling upon courts to set the amount of the royalty.[3] The courts in turn have articulated various principles for setting FRAND royalties, among them:

1. *See, e.g.*, IEEE-SA STANDARDS BOARD BYLAWS 6.2 (INST. OF ELEC. & ELECS. ENG'RS, INC. 2015), http://standards.ieee.org/develop/policies/bylaws/sb_bylaws.pdf; ETSI RULES OF PROCEDURE ANNEX 6, 6.2 (EUROPEAN TELECOMMS. STANDARDS INST. 2008), http://www.etsi.org/WebSite/document/Legal/ETSI_IPR-Policy.pdf; *see also* RUDI BEKKERS & ANDREW UPDEGROVE, A STUDY OF IPR POLICIES AND PRACTICES OF A REPRESENTATIVE GROUP OF STANDARDS SETTING ORGANIZATIONS WORLDWIDE 48–99 (Sept. 17, 2012), http://sites.nationalacademies.org/cs/groups/pgasite/documents/webpage/pga_072197.pdf (reporting the disclosure and licensing obligations among twelve leading SSOs as of 2012). In the literature and case law, the acronyms "RAND" and "FRAND" are used interchangeably. In this Article, we use the term "FRAND" (which appears to be gaining in popularity) unless we are quoting from a source that uses the alternative term "RAND."

2. A few SSOs require members to license SEPs on a royalty-free basis, but this does not appear to be the majority practice. *See* Jorge L. Contreras, *Technical Standards and Ex Ante Disclosure: Results and Analysis of an Empirical Study*, 53 JURIMETRICS 163, 173–75 (2013) (stating that some SSOs encourage or require members to disclose the maximum royalty rates they would seek). SSOs generally have avoided setting FRAND royalties for a variety of reasons. *But see* Doug Lichtman, *Understanding the RAND Commitment*, 47 HOUS. L. REV. 1023, 1027–29, 1046 n.65 (2010) (suggesting that "firms might prefer the ambiguous RAND commitment over a more conventional, explicit pricing term" due to "the desirable absence of lawyers," time constraints, lack of information about the value of the technology at the point in time at which a standard is adopted, and out of concerns over antitrust liability).

3. *See In re* Innovatio IP Ventures, LLC Patent Litig., No. 11 C 9308, 2013 WL 5593609 (N.D. Ill. Oct. 3, 2013) (determining the amount of a FRAND royalty in an infringement action); *see also* Microsoft Corp. v. Motorola, Inc., 795 F.3d 1024 (9th Cir. 2015) (reviewing the district court's "lengthy, thorough bench trial on the RAND rate and range"); Ericsson, Inc. v.

(1) The royalty should prevent SEP owners from exercising patent "hold-up."[4]

(2) Courts should minimize the risk of "royalty stacking," in which a seller incurs an excessive royalty burden as a result of marketing a product incorporating multiple, separately owned patents.[5]

(3) A FRAND royalty should reflect the incremental ex ante value of the technology in comparison with alternatives.[6]

D-Link Sys., Inc., 773 F.3d 1201 (Fed. Cir. 2014) (reversing a jury's determination of a FRAND royalty in a patent infringement action); Apple Inc. v. Motorola, Inc., 757 F.3d 1286 (Fed. Cir. 2014) (holding the expert's testimony regarding royalty rates was admissible and improperly excluded by the district court in an infringement action). Courts in Japan and China also have determined FRAND royalties. For further discussion, see Norman V. Siebrasse & Thomas F. Cotter, *Judicially Determined FRAND Royalties*, *in* 1 THE CAMBRIDGE HANDBOOK OF TECHNICAL STANDARDIZATION LAW (Jorge L. Contreras ed., forthcoming 2017).

4. *See Microsoft*, 795 F.3d at 1031, 1052 ("[T]he very purpose of the RAND agreement is to promote adoption of a standard by decreasing the risk of hold-up."), *aff'g* No. C10-1823JLR, 2013 WL 2111217, at *12 (W.D. Wash. Apr. 25, 2013) ("[A] proper methodology used to determine a RAND royalty should therefore recognize and seek to mitigate the risk of patent hold-up that RAND commitments are intended to avoid."); *Innovatio*, 2013 WL 5593609, at *8 ("[O]ne of the primary purposes of the RAND commitment is to avoid patent hold-up, which occurs when the holder of a standard-essential patent demands excess royalties after standard implementers are already locked into using the standard."); *cf. Ericsson*, 773 F.3d at 1234 ("The district court need not instruct the jury on hold-up or stacking unless the accused infringer presents actual evidence of hold-up or stacking.").

5. *See Microsoft*, 2013 WL 2111217, at *86 (stating that "RAND is informed by two prevailing concerns: preventing stacking and eliminating hold-up," and that "among these two goals, the anti-stacking principle is the primary constraint on the upper bound of RAND"); *see also Microsoft*, 795 F.3d at 1031; *Innovatio*, 2013 WL 5593609, at *9–10; *cf. Ericsson*, 773 F.3d at 1209 (acknowledging the potential for royalty stacking "when a standard implicates numerous patents"); *id.* at 1234 (affirming the district court's refusal to give a jury instruction on royalty stacking, for lack of evidence that stacking was a real, as opposed to a theoretical, issue that negotiating parties would have addressed). Royalty stacking can be viewed as a manifestation of the "Cournot complements" problem, which arises "when separate owners of complementary inputs each demand what is (for them) the individually profit-maximizing price, in exchange for permission to include those inputs in an end product," with the result that "the cost of producing the end product" will be "higher than the social optimum." Thomas F. Cotter, *Patent Holdup, Patent Remedies, and Antitrust Responses*, 34 J. CORP. L. 1151, 1169 (2009); *see also* FED. TRADE COMM'N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY, ch. 2, at 23 (2003); Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991, 2013 (2007) ("The Theory of Cournot complements teaches us that the royalty stacking problem is likely to be worse the greater the number of independent owners of patents that read on a product.").

6. *Innovatio*, 2013 WL 5593609, at *19 (stating that the court should "consider the utility and advantages of the patented property over alternatives

(4) The royalty should be proportionate to the technology's importance to the standard and to users of the standard (the "proportionality" principle).[7]

(5) The royalty should not reflect "any value added by the standardization of that technology," that is, "by the standard's adoption of the patented technology"[8]—or, as another court put it, simply, "the value of the standard."[9]

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that could have been written into the standard instead of the patented technology in the period before the standard was adopted," because "the presence of equally effective alternatives to the patented technology that could have been adopted into the standard will drive down the royalty that the patent holder could reasonably demand"); *Microsoft*, 2013 WL 2111217, at *13 (stating that "*ex ante* examination of the incremental contribution of the patented technology to the standard can be helpful in determining a RAND rate in the context of a dispute over a RAND royalty rate," and that "comparison of the patented technology to the alternatives that the SSO could have written into the standard is a consideration in determining a RAND royalty").

7. The court in *Microsoft* refers both to the importance of the patent to the standard and its importance to users' products. *Microsoft*, 2013 WL 2111217, at *3, *20 (characterizing as "central to the court's analysis" the principle "that the parties in a hypothetical negotiation would set RAND royalty rates by looking at the importance of the SEPs to the standard and the importance of the standard and the SEPs to the products at issue," and stating that "a patent that is extremely important and central to the standard would reasonably command a higher royalty rate than a less important patent"). The court in *Innovatio* merges the two. *Innovatio*, 2013 WL 5593609, at *8 ("[Because] the appropriate royalty base in this case is the Wi-Fi chip, [the purpose of which is] to provide 802.11 functionality, determining the importance of Innovatio's patents to the 802.11 standard also determines the importance of those patents to the Wi-Fi chip. Accordingly, the court's analysis does not include a separate section evaluating the importance of Innovatio's patents to the accused products, but instead merges that analysis into the inquiry about the importance of Innovatio's patents to the 802.11 standard."); *see also Ericsson*, 773 F.3d at 1232–33 ("Just as we apportion damages for a patent that covers a small part of a device, we must also apportion damages for SEPs that cover only a small part of a standard.").

8. *See Ericsson*, 773 F.3d at 1232 ("When dealing with SEPs, there are two special apportionment issues that arise. First, the patented feature must be apportioned from all of the unpatented features reflected in the standard. Second, the patentee's royalty must be premised on the value of the patented feature, not any value added by the standard's adoption of the patented technology. These steps are necessary to ensure that the royalty award is based on the incremental value that the patented *invention* adds to the product, not any value added by the standardization of that technology."); *see also* Commonwealth Sci. & Indus. Res. Org. v. Cisco Sys., Inc., 809 F.3d 1295, 1304 (Fed. Cir. 2015) (quoting *Ericsson*).

9. *Microsoft*, 795 F.3d at 1053 ("The fact that Motorola's patents were of minor import to the H.264 standard . . . was evidence from which the jury could infer that demanding a 2.25% royalty rate was not a good-faith effort to realize the value of the technology, but rather an attempt to capitalize on the value of the standard itself—that is, to obtain the hold-up value."); *Microsoft*, 2013 WL 2111217, at *10 ("The ability of a holder of an SEP to demand more

> (6) The royalty should be adequate to preserve the patent incentive (the "incentive to invent" principle).[10]
>
> (7) The royalty should provide an adequate incentive to participate in the standard setting process (the "incentive to participate" principle).[11]

Unfortunately, the courts have not been entirely clear about how one might go about trying to satisfy all of these principles (or whether doing so is even possible). Outside the FRAND context, courts often consider the fifteen amorphous *Georgia-Pacific* factors[12] to determine the amount of a reason-

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than the value of its patented technology and to attempt to capture the value of the standard itself is referred to as patent 'hold-up.'"); *see also Innovatio*, 2013 WL 5593609, at *8 (quoting *Microsoft*); Apple, Inc. v. Motorola, Inc., 869 F. Supp. 2d 901, 913 (N.D. Ill. 2012) ("The purpose of the FRAND requirements . . . is to confine the patentee's royalty demand to the value conferred by the patent itself as distinct from the additional value—the hold-up value—conferred by the patent's being designated as standard-essential."), *rev'd in part on other grounds*, 757 F.3d 1286 (Fed. Cir. 2014).

10. *See Innovatio*, 2013 WL 5593609, at *11 ("[A] RAND rate must be set high enough to ensure that innovators in the future have an appropriate incentive to invest in future developments and to contribute their inventions to the standard-setting process."); *Microsoft*, 2013 WL 2111217, at *80 ("[S]ince licensing through SSOs under the RAND commitment is, at least for some entities, an important component of profitability, reducing that component would reduce the incentive to innovate and thereby slow the pace of innovation in the economy."). The idea that damages should be adequate to preserve the patent incentive scheme is uncontroversial. *See, e.g.*, King Instruments Corp. v. Perego, 65 F.3d 941, 950 (Fed. Cir. 1995) ("[L]ost profits compensation . . . preserves constitutional incentives."); FED. TRADE COMM'N, THE EVOLVING IP MARKETPLACE: ALIGNING PATENT NOTICE AND REMEDIES WITH COMPETITION 52 (2011) ("The ability of patentees to allege patent infringement and enter ex post transactions is a necessary feature supporting the patent system's incentives to innovate. . . . Either royalty payments or an exclusive market position can allow a patentee to capture returns from its investment in making and developing an invention, which creates incentives for innovation."). Though whether that incentive is necessary to induce invention, disclosure, innovation, and other social benefits, and whether courts could in some instances adjust patent remedies to better ensure that the reward is commensurate with these benefits, are interesting, but separate issues. For discussion, see, for example, Ted Sichelman, *Purging Patent Law of "Private Law" Remedies*, 92 TEX. L. REV. 517, 554–69 (2014) (arguing that, ideally, courts would award damages sufficient to maintain the patent incentive, which could be higher or lower than the patentee's but-for damages).

11. *See Innovatio*, 2013 WL 5593609, at *11; *Microsoft*, 2013 WL 2111217, at *12 ("To induce the creation of valuable standards, the RAND commitment must guarantee that holders of valuable intellectual property will receive reasonable royalties on that property."); *see also* Anne Layne-Farrar et al., *Payments and Participation: The Incentives To Join Cooperative Standard Setting Efforts*, 23 J. ECON. & MGMT. STRATEGY 24 (2014) (discussing the impact of a licensing cap on standard setting).

12. *See* Georgia-Pac. Co. v. U.S. Plywood Co., 318 F. Supp. 1116, 1120

able royalty, a practice critics sometimes deride as enabling the trier of fact to award damages in almost any amount.[13] Does a similar risk arise that, by invoking the seven principles listed above, a court could characterize almost any damages award as consistent with FRAND terms? Are the principles themselves mutually consistent, or should some of them be modified or discarded? Might there be some deeper, foundational principle that could unite some or all of the above into a coherent whole?

This Article proposes, as a foundational principle, that a FRAND royalty should reflect *the incremental contribution of the patent to the value of the standard to the user*.[14] This principle combines three related ideas we develop and defend in the body of the Article. The first is that royalties should reflect the hypothetical bargain that reasonable parties would have struck ex ante (prior to incurring sunk costs) in light of the incremental value of the technology over unpatented alternatives as revealed ex post (an approach we refer to in a companion paper as "contingent ex ante").[15] Second, multiple patents reading on a standard should be valued in proportion to their marginal contribution to the standard (what we refer to below as "ex post Shapley pricing"). Third, the value of the standard to the user

(S.D.N.Y. 1970) (listing fifteen potentially relevant factors for calculating reasonable royalties), *modified on other grounds*, 446 F.2d 295 (2d Cir. 1971); *see also* Lucent Techs., Inc. v. Gateway, Inc., 580 F.3d 1301, 1324–36 (Fed. Cir. 2009) (applying the *Georgia-Pacific* factors).

13. *See, e.g.*, Christopher B. Seaman, *Reconsidering the* Georgia-Pacific *Standard for Reasonable Royalty Patent Damages*, 5 BYU L. REV. 1661, 1704 (2010) (providing an overview of the various sources of criticism). In the FRAND context, the courts in *Innovatio* and *Microsoft* both applied modified versions of the *Georgia-Pacific* factors. *See Innovatio*, 2013 WL 5593609, at *5–8; *Microsoft*, 2013 WL 2111217, at *17–20.

14. Some other commentators have proposed that a FRAND royalty should reflect the marginal or incremental contribution of the patent to the standard. *See, e.g.*, Anne Layne-Farrar et al., *Pricing Patents for Licensing in Standard-Setting Organizations: Making Sense of FRAND Commitments*, 74 ANTITRUST L.J. 671, 693 (2007); J. Gregory Sidak, *The Meaning of FRAND, Part I: Royalties*, 9 J. COMPETITION L. & ECON. 931, 980–81 (2013). However, as will become apparent in the text above, the meaning they accord this principle is materially different from ours.

15. Norman V. Siebrasse & Thomas F. Cotter, *A New Framework for Determining Reasonable Royalties in Patent Litigation*, 68 FLA. L. REV. (forthcoming 2017), http://ssrn.com/abstract=2528616. To be more precise, under the contingent ex ante approach the patentee is entitled to the value of the patented technology ex ante (that is, prior to incurring sunk costs) given that the patent is chosen for inclusion in the standard, over the value of the next-best unpatented technology ex ante had *that* technology been chosen for inclusion in the standard. *See infra* note 42, Part III.A, Appendix B.

determines the user's maximum willingness to pay. The user is not interested in licensing patent rights as such; what the user wants is the right to use the standard.[16] The amount the user is willing to pay for that right therefore depends on the value of the standard to the user, not on matters such as how many patents read on the technology, whether those patents are held by one patentee or by many, whether the standard was formally developed by an SSO or arose de facto, or whether the value results from widespread adoption due to network effects, efficient design, or the whims of fashion. None of these factors affect the value of the standard to the user, and consequently, none should affect the reasonable royalty the user is required to pay. As we will show, our approach is more firmly grounded in innovation policy than any of the competing approaches advanced to date. Moreover, our proposal provides a foundation for interpreting the seven principles articulated above that will enable courts to apply those principles in a coherent and consistent manner.

The key to understanding our approach rests on unpacking Principle (5)'s reference to the "value of the standard." As we will show, courts and others have used this or similar terms in reference to three distinct phenomena, which we refer to as "sunk costs holdup," "network value appropriation," and the "apportionment problem." Sunk costs holdup may arise whenever the adoption of a standard requires users to incur investment-specific sunk costs. Here the concern is that a patentee armed with an injunction might be able to extract some portion of those sunk costs, above and beyond the value of its invention.[17] So understood, sunk costs holdup is not limited to the standards context—or even the patent context—though in practice standards often do require implementers to make transaction-specific investments. Consequently, in some sense sunk costs holdup can be (and sometimes is)[18] described as capturing

16. *See* David O. Taylor, *Using Reasonable Royalties To Value Patented Technology*, 49 GA. L. REV. 79, 116–18 (2014) (arguing that the fundamental goal of patent remedies should be to accurately value the patented technology, because doing so serves the public policy purpose of providing optimal incentives to invent).

17. *See* Joseph Farrell et al., *Standard Setting, Patents, and Hold-Up*, 74 ANTITRUST L.J. 603, 612–13 (2007); *see also infra* Part I.

18. *See* Microsoft Corp. v. Motorola, Inc., 795 F.3d 1024, 1031, 1053 (9th Cir. 2015); FED. TRADE COMM'N, *supra* note 10, at 5; NAT'L RESEARCH COUNCIL OF THE NAT'L ACADEMIES, PATENT CHALLENGES FOR STANDARD-SETTING IN THE GLOBAL ECONOMY 62–63 (Keith Maskus & Stephen A. Merrill eds.,

the value of standardization, although strictly what is captured by the patentee is some part of the user's sunk costs that are incurred on standardization.

The second phenomenon, network value appropriation, arises whenever the value of a particular technology increases upon standardization due to the presence of network effects.[19] As with sunk costs holdup, an injunction would enable the patentee to extract a higher royalty ex post than it could have negotiated ex ante, and thus this too might be described as resulting in the capture of some of the value of the standard—though in this context, the increase in value is due to network effects and does not depend on the presence of transaction-specific sunk costs.

While both of the preceding phenomena could arise even when a standard incorporates just a single patent, the apportionment problem arises when a standard embodies multiple patents, each of which contributes only some portion of the overall value of the standard. Because each patent is essential[20] to the implementation of the standard, one patentee armed with an injunction can capture the full value of the standard from a user, even though it adds only a small part of the value of the standard. The apportionment problem does not depend on transaction-specific investments by the user; rather it turns,

2013); THE SEDONA CONFERENCE, COMMENTARY ON PATENT DAMAGES AND REMEDIES, PUBLIC COMMENT VERSION 26–27 (2014).

19. *See infra* notes 44–45 and accompanying text.

20. Many patents declared to be essential are not in fact essential. *See, e.g.*, FAIRFIELD RES. INT'L, INC., REVIEW OF PATENTS DECLARED AS ESSENTIAL TO LTE AND SAE (4G WIRELESS STANDARDS) THROUGH JUNE 30, 2009, at 2 (2010), http://www.frlicense.com/LTE%20Final%20Report.pdf (reporting that only fifty percent of 210 declared-essential patents studied were essential as judged by the authors' panel of experts). We exclude such patents on the view that, in principle, a user can resist any excessive royalty demands that turn on essentiality by showing that the patent is not essential. (Note that the user nonetheless might be subjected to excessive demands based on sunk costs holdup, as this does not depend on the patent being essential.) Further, a patent may also be essential to either a mandatory or optional part of the standard; IEEE-SA Bylaw 6.1, for example, defines both to be "essential." IEEE-SA STANDARDS BOARD BYLAWS 6.1 (INST. OF ELEC. & ELECS. ENG'RS, INC. 2015), http://standards.ieee.org/develop/policies/bylaws/sb_bylaws.pdf. We will use the term essential to mean a patent that is essential to the standard as implemented by the user. That includes all patents that are essential to mandatory aspects of the standard, and all patents that are essential to an optional part if that option is implemented by the particular user. A user will not be liable to pay any excessive royalty—or indeed any royalty—for a patent that is essential to an optional part of the standard that the user does not implement, because it will not infringe.

albeit indirectly, on network effects, because the patentee's ability to demand more than the value of its own contribution derives from the fact that the user would have to abandon the standard if it does not license the patent.[21] The three phenomena can be compared and contrasted using the following table[22]:

Table 1: Three Distinct Phenomena

Feature / Phenomenon	Transaction-specific investment by users	Network effects	More than one patent
Sunk costs holdup	REQUIRED	NOT REQUIRED	NOT REQUIRED
Network value appropriation	NOT REQUIRED	REQUIRED	NOT REQUIRED
Apportionment	NOT REQUIRED	REQUIRED	REQUIRED

We argue that these three phenomena have distinct policy implications. While all can be described as involving holdup, in the loose sense that a patentee armed with an injunction can obtain a higher royalty after standardization than before, the economic implications—and, consequently, the appropriate response—are very different. Sunk costs holdup has adverse effects on both user behavior, by making investment riskier, and on inventor behavior, by creating an excessive incentive to patent.[23] Sunk costs holdup is appropriately addressed by use of an

21. One might imagine that the user could avoid the apportionment problem simply by redesigning its product to avoid using a patented technology that contributes little or no value to that particular user, especially if the ability to advertise that its product is standard-compliant is not commercially valuable. However, the licensing terms for the *other* patents that are essential to the standard will typically contain a term specifying that the license extends only to products that comply with the standard, which means that the user cannot abandon a minor technology without abandoning the important technologies at the same time. *See* STANDARDS DEVELOPMENT PATENT POLICY MANUAL 60–61 (AM. BAR ASS'N COMM. ON TECH. STANDARDIZATION SECTION OF SCI. & TECH. LAW) (discussing clause k).

22. "Required" in the table means that a feature (e.g., network effects) *must* be present for the phenomenon (e.g., network value appropriation) to exist, whereas "Not Required" means that the phenomenon (e.g., sunk costs holdup) is not dependent on the feature (e.g., network effects). "Not Required" does not imply that the feature is irrelevant. Network effects may exacerbate sunk costs holdup, for example, even though sunk costs holdup is not dependent on the presence of network effects.

23. *See infra* Part II.C.

ex ante hypothetical negotiation framework, in which the parties are assumed to bargain before any sunk costs are incurred.[24] By contrast, network value appropriation does *not* have any adverse effects on either user or patentee behavior, other than those that are inherent in the patent system generally. Consequently, network value appropriation is not a concern that should be addressed in assessing FRAND royalties, and it is a mistake to conflate this phenomenon with sunk costs holdup. Indeed, we argue that the incentive-to-invent and incentive-to-participate principles require that the SEP owner *should* be able to capture some portion of the network effects (if any) arising from standardization, though not the sunk costs. Thus, we recommend that, in contrast to the "pure" or incremental ex ante approach as embodied in Principle (3), courts should construct the bargain the patentee and the implementer would have negotiated ex ante (thus avoiding sunk costs holdup), but with awareness of all relevant information that is revealed ex post, including the fact that the patent was incorporated into the standard.

Finally, the apportionment problem has adverse effects on patentee behavior by potentially overcompensating minor inventions and on user behavior to the extent it contributes to royalty stacking.[25] Moreover, because the apportionment problem relates to the division of royalties among patentees, it is not properly addressed by the timing of the negotiation between the patentee and the user. Instead, we argue, it should be addressed by ex post Shapley pricing, which applies the well-established economic concept of Shapley pricing[26] to the patents actually selected to be part of the standard, in order to assess the relative value of various contributions to a standard in a manner that is both intuitively appealing and sound in terms of economic incentives. In particular, ex post Shapley pricing provides a way to estimate the value of individual SEPs that satisfies both the proportionality principle and the "avoid royalty stacking" principle, while also enabling a reasoned interpretation of what it *should* mean for courts to avoid basing FRAND royalties on "the value of the standard."[27]

24. *See infra* note 43.
25. *See infra* Part III.B.
26. *See infra* Part II.E.
27. *See infra* Part III.C.

Put another way, when coupled with the contingent ex ante approach, ex post Shapley pricing results in a royalty that reflects *the incremental contribution of the patent to the value of the standard to the user*. This has both positive and negative implications for the existing theories of how to calculate FRAND royalties.[28] On the one hand, under our proposal a patentee cannot capture more than the patent's incremental contribution to the value of the standard, as the "ex ante" aspect ensures that the patentee cannot capture any part of the user's sunk costs. To that extent, our approach reflects the established consensus. On the other hand, we reject the common view that the patentee should be confined to the value of its technology prior to standardization and argue instead that the patentee should be able to capture some portion of the invention's increase in value attributable to network effects, as revealed ex post. Importantly, Shapley pricing ensures that any individual patentee is confined to its incremental contribution to that value. The application of Shapley pricing ex post (to the patents actually selected for inclusion in the standard) is consistent with the principle of conditioning the hypothetical negotiation on knowledge of which patents actually were selected to be part of the standard, and also is intended to maintain the appropriate incentive to invent.

To be sure, our proposed approach, like most idealized models, probably cannot be directly implemented in practice. It is nonetheless useful as a conceptual benchmark for assessing the merits of more practical methodologies and comparators, which should serve as proxies for the theoretical ideal.[29] Our approach also provides a principled way of interpreting the valuation principles articulated in the emerging case law, as well as the recently adopted IEEE-SA Bylaws (which, like some of the cases cited above, states that a FRAND royalty should not include the value resulting from a patent's inclusion in a standard).[30] Properly understood, these statements should preclude courts from awarding royalties based on sunk costs

28. *See infra* Part III.D.

29. *See infra* Part III.D.

30. *See* IEEE-SA STANDARDS BOARD BYLAWS 6.1 (INST. OF ELEC. & ELECS. ENG'RS, INC. 2015), http://standards.ieee.org/develop/policies/bylaws/sb_bylaws.pdf. (defining a "Reasonable Rate" as meaning "appropriate compensation to the patent holder for the practice of an Essential Patent Claim excluding the value, if any, resulting from the inclusion of that Essential Patent Claim's technology in the IEEE Standard").

holdup, and from allowing SEPs that add little value to a standard to capture a substantial portion of the standard's ex post value—though not from allowing the recovery of some portion of the value added by standardization.

Part I below distinguishes the concepts of sunk costs holdup and network value appropriation, while Part II critiques the "auction model" that is the best known formal model of the incremental ex ante approach. Part III then lays out our proposed framework, under which the royalty reflects the incremental contribution of the patent to the value of the standard to the user and its implications for real-world practice.

I. SUNK COSTS HOLDUP AND NETWORK VALUE APPROPRIATION

We begin our analysis by distinguishing between "sunk costs holdup," which depends on technology-specific investments made by the user,[31] and "network value appropriation," which depends on network effects.[32] The fact that the mechanisms giving rise to these phenomena are distinct is not in itself a novel point, but the distinction nonetheless is routinely overlooked in the SEP literature.[33]

The problem of sunk costs is not confined to the standards context, or even to patents. It arises whenever a transaction is subject to "durable investments in transaction-specific human or physical assets" made by at least one party.[34] For convenience, we will refer to transaction-specific investments as "sunk costs," where the transaction specificity is left implicit. If the rights of the party who has made asset-specific investments are not fully defined prior to those investments being made ("ex ante"), that party may be subject to having the terms of the transaction (re-)negotiated in a way that allows the counterparty to capture some part of the value of the sunk costs.[35]

31. *See* Farrell et al., *supra* note 17, at 612–14.

32. *See infra* notes 44–45 and accompanying text.

33. *See* Sidak, *supra* note 14, at 1022; *supra* text accompanying note 18.

34. *See* OLIVER E. WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM: FIRMS, MARKETS, RELATIONAL CONTRACTING 61 (1985).

35. *See id.* at 64–67 (developing the theory of opportunism based on asset-specificity as an explanation for vertical integration, and noting that in the long-term the fact that supply arrangements need to adapt to changing environmental conditions implies that the terms of a contractual supply agreement cannot be fully negotiated ex ante). *See generally* Oliver E. Williamson, *The Vertical Integration of Production: Market Failure Considerations*, 61 AM.

An example of this phenomenon in the non-SEP patent context is provided by *Riles v. Shell Exploration & Production Co.*[36] The invention at issue related to a method for installing the foundation for an oil drilling platform.[37] Shell had built such a platform but was found to have infringed Riles' patent when it placed the foundations.[38] The value of the patented method over alternative noninfringing methods was roughly $350,000.[39] Accordingly, had the parties negotiated a license ex ante, before work on the foundations had commenced, Shell would not have been willing to pay more than that amount for the right to use the patented method. Once the foundations were in place, the platform was built on top at a cost of $84 million.[40] Had an injunction been available to enjoin the use of the platform in consequence of the infringement, Shell would have been willing to pay more than $84,000,000 for the right to use the invention, even though the value of the patented invention itself was only the $350,000 cost advantage it provided over the best available alternative.[41] This potential to capture some of the infringer's sunk costs is what we mean by "sunk costs holdup."[42]

ECON. REV. 112 (1971) (discussing vertical integration in a firm context).

36. Riles v. Shell Expl. & Prod. Co., 298 F.3d 1302 (Fed. Cir. 2002).

37. *Id.* at 1305.

38. *Id.* at 1306.

39. *See id.* at 1313 (noting Shell's evidence to that effect). The evidence was contested, but for purposes of this example it is sufficient that it is plausible that the value of the invention as compared with the alternative is substantially less than the value of the platform itself.

40. *See id.* at 1311.

41. This assumes the project would be profitable even using the alternative technology, so that walking away entirely does not make sense. In that case, licensing saves the $84,000,000 cost of a new platform, plus the cost of placing new foundations with non-infringing technology.

42. More precisely, what we refer to in the text above as "sunk costs holdup" arises when the patentee armed with an injunction can extract the user's sunk costs plus the opportunity cost of not having chosen a noninfringing alternative ex ante. For a formal analysis, see Norman Siebrasse & Thomas Cotter, *Why Switching Costs Are Irrelevant to Patent Holdup*, COMP. PAT. REMEDIES BLOG (Sept. 24, 2015), http://comparativepatentremedies.blogspot.com/2015/09/why-switching-costs-are-irrelevant-to_24.html. For other illustrative examples of sunk costs holdup, see Dennis W. Carlton & Allan L. Shampine, *An Economic Interpretation of FRAND*, 9 J. COMPETITION L. & ECON. 531, 538–41 (2013); Farrell et al., *supra* note 17, at 616; Anne Layne-Farrar et al., *Preventing Patent Hold Up: An Economic Assessment of Ex Ante Licensing Negotiations in Standard Setting*, 37 AIPLA Q.J. 445, 455–57 (2009); Lemley & Shapiro, *supra* note 5, at 2001–02.

In practice, U.S. courts can reduce the risk of holdup by exercising their discretion to deny injunctive relief in cases like *Riles*.[43] Note, however, that if the court were to award (or the parties were to negotiate) a reasonable royalty based on the amount that a patentee would be able to extract if armed with an injunction, the holdup problem would re-emerge. For this reason, the reasonable royalty should be (and is) assessed by means of an ex ante hypothetical negotiation, which is assumed to take place before the user has incurred any sunk costs.

Network value appropriation, by contrast, depends on network effects. Network effects arise when the value a user derives from consumption of a good increases with the number of other agents consuming the good.[44] Communication technologies are a classic example: the more people that have telephones, the more valuable a telephone is to any given person.[45] While network effects may arise in the absence of standards, and de facto standards may arise as a consequence of network effects even in the absence of formal standards, a major reason for the existence of formal standards is to allow the market to coordinate on a single technology in order to reap the benefits of network externalities.[46] Consequently, formal standards are normally associated with network effects.

When network effects are significant, adoption of a standard increases the value of the market by enabling parties to coordinate on a common technology.[47] Prior to standardization, no single patentee acting independently can capture any part of the value derived from standardization, absent foreknowledge that its patent (as opposed to someone else's) will be selected

43. *See* eBay Inc. v. MercExchange, LLC, 547 U.S. 388, 396–97 (2006) (Kennedy, J., concurring). Also, on the facts in *Riles*, the Federal Circuit held that Shell could not be enjoined from using the platform on the basis of the infringement of the method patent, because any injunction must be tailored to the specific infringement, though this particular response will not be generally applicable. 298 F.3d at 1311–12. Applying a well-established rule, the court in *Riles* also held damages in the form of a reasonable royalty must be based on a hypothetical negotiation taking place ex ante, before any asset-specific investments are made, precisely so that the patentee is prevented from capturing any of the holdup value associated with the asset-specific investments made by the infringer. *See id.* at 1313. On the ex ante hypothetical negotiation, see generally Siebrasse & Cotter, *supra* note 15.

44. *See* Michael L. Katz & Carl Shapiro, *Network Externalities, Competition, and Compatibility*, 75 AM. ECON. REV. 424, 424 (1985).

45. *See id.*

46. *See id.* at 434.

47. *See id.*

for inclusion in the standard.[48] After standardization, however, a patentee whose technology is included in the standard can extract a royalty that reflects the widespread use of that technology due to network effects.[49] We refer to the ability of the patentee to capture the value added by standardization as "network value appropriation." As with sunk costs holdup, a patentee armed with an injunction can extract more from a user ex post than it would have been able to extract ex ante (before the sunk costs were incurred or the standard adopted).

Sunk costs holdup and network value appropriation often occur together, because the adoption of a particular standard often requires (or at least invites) technology-specific investments. For this reason, and because both phenomena enable patent owners to extract higher royalties ex post than they would have been able to extract ex ante, they often are treated as a single problem warranting the same solution. For example, in an influential paper Daniel G. Swanson and William J. Baumol propose that a (F)RAND royalty is one that approximates the outcome of an ex ante auction in which patents compete to be included in the standard.[50] At the conclusion of such an auction, each "winning" patent would be entitled to a royalty equal to its incremental value over the next-best alternative that was available ex ante.[51] At first blush, this "incremental ex ante" approach seems appealing because it evokes the widely accepted principle that reasonable royalty awards should equal the amount to which a willing licensor and licensee would have agreed ex ante—before the patent was infringed or, in the present context, before the standard was adopted—in view of the advantages of the patented technology over other alternatives.[52]

48. *See id.* at 435.

49. U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, ANTITRUST ENFORCEMENT AND INTELLECTUAL PROPERTY RIGHTS: PROMOTING INNOVATION AND COMPETITION 7 (2007), https://www.justice.gov/sites/default/files/atr/legacy/2007/07/11/222655.pdf.

50. Daniel G. Swanson & William J. Baumol, *Reasonable and Nondiscriminatory (RAND) Royalties, Standards Selection, and Control of Market Power*, 73 ANTITRUST L.J. 1, 6 (2005); *see also* Layne-Farrar et al., *supra* note 14, at 688–93 (extending the Swanson-Baumol model).

51. *See* Swanson & Baumol, *supra* note 50, at 15–21.

52. *See* Lucent Techs., Inc. v. Gateway, Inc., 580 F.3d 1301, 1324–25 (Fed. Cir. 2009) ("[T]he hypothetical negotiation or the 'willing licensor-willing licensee' approach[] attempts to ascertain the royalty upon which the parties would have agreed had they successfully negotiated an agreement just before infringement began[, recreating] as best as possible . . . the *ex ante* licensing negotiation scenario and . . . resulting agreement."); Georgia-Pac. Co. v. U.S.

As Swanson and Baumol argue, this approach would prevent SEP owners from engaging in patent "holdup" by demanding ex post royalties that are higher than the royalties to which they would have agreed at an ex ante auction.[53] But the approach treats both network value appropriation and sunk costs holdup in the same way. Thus, while Swanson and Baumol explicitly identify what we are referring to as sunk costs holdup and network value appropriation as distinct mechanisms by which an SSO's selection of a patent "may have economic effects that convert a previously competitive technology market into one that is subject *ex post* to market or monopoly power,"[54] they view the two phenomena as giving rise to a unified problem, namely "the problem of *ex post* market power."[55]

Plywood Co., 318 F. Supp. 1116, 1120 (S.D.N.Y. 1970), *modified on other grounds*, 446 F.2d 295 (2d Cir. 1971). In the SEP context, courts have begun to shift the time frame for the hypothetical negotiations, from just before the patent was infringed to just before the standard was adopted. *See In re* Innovatio IP Ventures, LLC. Patent Litig., No. 11 C 9308, 2013 WL 5593609, at *19 (N.D. Ill. Oct. 3, 2013); Microsoft Co. v. Motorola, Inc., No. C10-1823JLR, 2013 WL 2111217, at *19 (W.D. Wash. Apr. 25, 2013), *aff'd*, 795 F.3d 1024 (9th Cir. 2015); Apple Inc. v. Motorola, Inc., 869 F. Supp. 2d 901, 913 (N.D. Ill. 2012), *rev'd in part on other grounds*, 757 F.3d 1286 (Fed. Cir. 2014).

53. Swanson & Baumol, *supra* note 50, at 10–11 ("If the primary goal of obtaining RAND licensing commitments is to prevent IP holders from setting royalties that exercise market power created by standardization, then the concept of a 'reasonable' royalty for purposes of RAND licensing must be defined and implemented by reference to *ex ante* competition, i.e., competition in advance of standard selection.").

54. *Id.* at 9–10.

55. *Id.* at 15. Some other work similarly specifically identifies both sunk costs holdup and network value appropriation as distinct phenomena. For example, a joint report of the U.S. Department of Justice and the Federal Trade Commission explicitly distinguishes what we have called sunk costs holdup and network value appropriation, but then treats them as a single problem creating a distinction between "the licensing terms a patent holder could obtain solely based on the merits of its technology and the terms that it could obtain because its technology was included in the standard." U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, *supra* note 49, at 38–39 & n.25. More commonly, however, the two phenomena are not explicitly distinguished. Some authors simply define holdup as "a demand for higher royalties or other more costly licensing terms after the standard is implemented than could have been obtained before the standard was chosen." Request for Comments and Announcement of Workshop on Standard-Setting Issues, 76 Fed. Reg. 28,036 (Fed. Trade Comm'n May 13, 2011). Others use similar terms that encompass both sunk costs holdup and network value appropriation. Indeed, most of the articles referring to patent holdup provide examples that are specific to sunk costs holdup alone. *See, e.g.*, Jorge L. Contreras & Richard J. Gilbert, *A Unified Framework for RAND and Other Reasonable Royalties*, 30 BERKELEY TECH. L.J. 1451, 1487 (2015); Lemley & Shapiro, *supra* note 5, at 2001–02. We

Treating sunk costs holdup and network value appropriation alike would not be problematic if they gave rise to the same functional problem; we do not dispute that both phenomena allow an SEP owner to charge more after the standard is adopted than it could have charged ex ante. We nevertheless claim that "holdup" in this sense alone is not a problem. More precisely, *sunk costs holdup* results in inefficient user and patentee behavior.[56] However, *network value appropriation* has no static efficiency implications beyond those that arise from the above-marginal cost pricing that is fundamental to the patent system and is actually desirable from a dynamic efficiency perspective. Consequently, to treat them together is to conflate two functionally different issues.

An example is useful to understand our objection. Consider a stylized wireless local area network (WLAN) technology. Assume that there are network externalities, so that the more users there are of a particular Wi-Fi technology, the more any individual user will be willing to pay to license that technology. To isolate the issue of network value appropriation, assume that only one patented technology is required to implement the Wi-Fi technology (which allows us to ignore both royalty stacking and the problem of apportionment). Assume further that the user's marginal cost of implementing Wi-Fi technology, apart from any royalty, is negligible.[57] This allows us to ignore the problem of sunk costs for the moment. Assume that all users are identical, so that the "nondiscriminatory" part of the FRAND requirement need not be addressed. Also assume that

do not disagree with these papers' conclusions that sunk costs holdup should be avoided. Our argument is simply that standardization gives rise to another phenomenon, network value appropriation, which does not threaten the same inefficiencies as sunk costs holdup.

56. There is a lively debate as to how serious the sunk costs problem in fact is in the context of SEPs. *Compare, e.g.*, Alexander Galetovic et al., *An Empirical Examination of Patent Hold-Up*, 11 J. COMPETITION L. & ECON. 549, 550 (arguing that patent holdup is not a serious problem), *with* Lemley & Shapiro, *supra* note 5, at 2025–35 (arguing that patent holdup is a serious problem). By saying the problem of sunk costs holdup is "real," we do not mean to be taking any position on this empirical question. We mean only that the problem can arise, and must be addressed, even though the ultimate conclusion may be that in practice it is not sufficiently serious to warrant a specific legal response.

57. Perhaps all of the competing technologies are embodied on an easily removable chip, similar to a cell phone SIM card. This is itself inexpensive apart from any royalties associated with the embodied technology, so that switching from one technology to another is simply a matter of switching the card.

the technology has no other application so if it is not incorporated into the patent it is worthless. This means we do not need to consider the patentee's incentive to participate, because the patentee's outside option is always less than (or at most, equal to) the value of participating. Finally, assume that the patentee's marginal cost of implementing the technology is also zero. This simplifies the numerical examples by fixing the minimum royalty a patentee is willing to accept at zero.

In Scenario 1 the market is mature, but fragmented: there are ten firms that have developed and patented WLAN technology, *A*, *B*, . . . *I*, *J*, all of which are equally good. Each of the ten technologies has been adopted by one hundred users who use it in isolated networks, such as within a single firm. Each user would be willing to pay up to $10 annually for a license to the patented technology it has adopted, but the users and the patentees have equal bargaining power, so each user has licensed the technology from its respective patentee for $5 annually and each patentee receives $500.[58] The total consumer surplus is $5000 and the total royalty income received by all the patentees is $5000, so the total social value of WLAN in the fragmented market is $10,000. While WLAN is useful in the isolated networks, it would be even more useful if standardized, so that individual users could use their WLAN not just at their own office, but also at outside meetings and coffee shops. Each of the thousand users would be willing to pay $100 annually for exactly the same technology they are currently using if all other users were also using the same technology. Also because the technologies are all equally good and switching costs are negligible, any user would be happy to adopt any of the ten technologies if everyone else did so as well. Coordination problems are all that is stopping a standard from emerging. An SSO is set up and solves the coordination problem by choosing technology *A*, which is then adopted by all users. The total annual social value of WLAN technology is now $100,000.

58. This reflects the usual view that the royalty will fall in the bargaining range defined by the patentee's marginal cost, which we assume for convenience to be zero, and the user's maximum willingness to pay, which is determined by the value of the invention as compared with the best alternative (which, in this example, we have assumed to be $10). A $5 royalty, which falls in the middle of the bargaining range, would be the Nash Bargaining Solution if the parties have equal bargaining power. However, nothing in our analysis turns on the Nash Bargaining Solution; any other number in the bargaining range would serve equally well.

If patentee *A*, whose technology was adopted as the standard, was able to obtain an injunction against any party using the standard, *A* would be able to extract up to $100 from each user. Patentee *A* could not extract more, because a user would prefer to pay $10 to use a non-standard technology within its firm, rather than pay more than $100 to use the standard technology anywhere. But the user would strictly prefer to adopt the standard technology *A* for any royalty less than $100. The exact amount of the license will depend on the relative bargaining power of the parties. If the parties have the same bargaining power as in the fragmented market, *A* would be able to license the same technology to each user for $50 annually, for a total of $50,000, even though before standardization it was only able to charge $5 to its own users, for a total of $500.[59]

As discussed above, it has become a commonplace to state that *A* is entitled to the (incremental) "value of the patented technology" itself, as contrasted with the value that arises from standardization, but the cases do not specify exactly what is meant by either concept.[60] The value of standardization is presumably the difference between the value of the standard and the value of the patented technology, but both of these concepts are ambiguous. The "value of the standard" in the present example could be understood as the $100,000 social value of the standardized technology in Scenario 1, or it might be understood as the amount that a patentee armed with an injunction could actually extract (which, if the parties had equal bargaining power, would be $50,000). The value of the invention could be understood as the $500 that patentee *A* was in fact receiving annually prior to standardization. Or it might be the ex ante consumer surplus, which is $1000 in our example. It might even be argued that the value of the technology is equal to the full value of the market to all patentees prior to standardization ($5000), or even the full social value prior to standardization ($10,000), based on the view that WLAN technology is

59. Since bargaining power may reflect risk-aversion, it is not strictly correct to assume that the parties will have the same bargaining power in the standardized market as in the fragmented market. *See, e.g.*, JON ELSTER, THE CEMENT OF SOCIETY: A THEORY OF SOCIAL ORDER 80–81 (1989). We assume that the bargaining power remains the same simply for numerical convenience. Nothing turns on the point; our argument turns only on the point that the patentee whose technology is selected as the standard is able to extract more ex post, in the standardized market, than it could have demanded ex ante, in the fragmented market.

60. *See supra* notes 8–9.

worth that much even if not standardized. Alternatively, we might take it to be the amount that patentee *A* would have been willing to accept in an ex ante negotiation between the parties in order to be selected as the standard. This amount depends on the details of the hypothetical negotiation. As we will see, in Swanson & Baumol's model this would be $0 on the facts in Scenario 1.[61] Whether the value of the patented technology is taken to be $0, $500, $1000, $5000 or $10,000, does not affect our basic point. We will argue that even a substantially higher royalty—say, one in which the patentee and the users share equally in the additional value created by standardization—could be considered fair and reasonable. With that said, the ambiguity as to what actually constitutes the value of standardization signals an important conceptual problem, to which we will return in due course.

Now consider Scenario 2, in which initially there is no WLAN at all. The same firm *A* as in Scenario 1 develops and patents the same technology *A*, but in Scenario 2, no other firm develops a competing technology. As in Scenario 1, each user's maximum willingness to pay for a standardized technology is $100, but in this scenario technology *A* is the de facto standard, so users are willing to pay up to that amount to license from patentee *A* when it first develops the technology. After bargaining, the parties agree to a royalty of $50.[62] The result is that in Scenario 2, *A* will reap $50,000 of the $100,000 social value of the de facto standardized WLAN market.

In Scenario 2 we would not say there is anything wrong with *A* capturing a substantial part of the social value of the technology.[63] On the contrary, this is a classic example of the patent system working the way it should: the patentee invents a valuable product, charges what the market will bear and is rewarded accordingly. Even if subsequent patentees *B* through

61. *See* Swanson & Baumol, *supra* note 50, at 19 (describing a formula on recurring costs and licensing fees); *see also* Layne-Farrar et al., *supra* note 14, at 690.

62. Our analysis depends only on the point that the parties will split the incremental value of the invention between them, and for a very wide range of plausible outcomes the patentee will receive more than $10 per user. A royalty of $10, $1, or $0, which are the salient points in the context of Scenario 1, are entirely arbitrary in the context of Scenario 2.

63. Note that this does not mean that *A* captures the entire value of the invention or the entire consumer surplus. Presumably there will be some consumer surplus accruing to the users, but we do not normally worry about whether there is consumer surplus or not.

J then develop their equivalent alternative technology (call this Scenario 2B), no user will be willing to adopt that technology, because it offers no technical advantage over technology *A*, and the network effect value will be lost if they switch.[64] In effect, the only difference between Scenario 1 and Scenario 2 is that in Scenario 2 historical accident solved the coordination problem, while it needed to be solved by an SSO in Scenario 1.[65]

There is a puzzle here. Why should it be a paradigmatic example of a properly functioning patent system for patentee *A* to receive a royalty of $50 per user in Scenario 2, and yet a basic principle of FRAND royalties that the same patentee with the same technology should not be entitled to more than $10 per user, perhaps even less, in Scenario 1?

One obvious difference between the cases is that in Scenario 2, it is intuitive to say that the entire value of the market was created by patentee *A*, while in Scenario 1, the value of the standardized market was evidently created by standardization, not by patentee *A*, whose technology was selected arbitrarily. From a fairness perspective, it might seem that in Scenario 2, patentee *A* is deservedly capturing the value of its own invention, while in Scenario 1 it is undeservedly capturing the value of standardization. But if we look at matters from the perspective of the users, there is an equally intuitive counterargument: it seems unfair that the users capture almost the entire value of the technology in Scenario 1, when they have contributed nothing at all to the development of that technology.[66]

64. Even if *B* offers to license for $0, users will not switch, because their individual surplus will be only $10 (the value of using an isolated network), whereas the user surplus is $50 if they license the de facto standard technology from *A* for $50. At most, the ex post competition will ensure that *A* cannot demand more than $90 for its technology.

65. *See* Joshua D. Wright, *SSOs, FRAND, and Antitrust: Lessons from the Economics of Incomplete Contracts*, 21 GEO. MASON L. REV. 791, 794 (2014) (noting the functional equivalent between standard setting through an SSO and through a "standards war").

66. *Cf.* Damien Geradin & Anne Layne-Farrar, *The Logic and Limits of Ex Ante Competition in a Standard Setting Environment*, 3 COMPETITION POL'Y INT'L 79, 93 (2007) (noting that consumers reap the benefits of standardization).

II. CRITIQUE OF THE AUCTION MODEL

A. GENERAL CONSIDERATIONS

As noted, Swanson and Baumol identify both sunk costs holdup and network value appropriation as creating ex post market power.[67] They perceive this as a problem (for reasons we discuss below), and they provide a single response, namely an auction model in which patentees bid to be selected for the standard by making offers, via the SSO, to downstream users who then select the bid which provides the end user with the greatest net profit.[68] The patentee with the winning bid is selected to be part of the standard. In the auction model, because the parties bid before the standard is adopted and are then locked in to their bid, ex ante competition between the parties constrains the price that can be charged ex post.[69] The basic result of the auction model, which Swanson and Baumol propose as a "reasonable" royalty for FRAND purposes,[70] is that the patent will be licensed at a fee "equal to the recurring costs of licensing, plus the difference in value between the best and next-best IP alternatives."[71] This result was reflected in the expert testimony that Judge Robart adopted in *Microsoft v. Motorola*:

> Dr. Schmalensee has likewise acknowledged that, in the event of a dispute regarding RAND royalties, "[t]he various parties could make their cases in court for the relative value of their IP contributions to the standard, *in the context of other options considered during the standard's early development phases.* If a component had multiple alternatives before the standard was settled, its incremental contribution, properly measured, may be close or equal to zero."[72]

67. *See supra* notes 53–54 and accompanying text.

68. *See* Swanson & Baumol, *supra* note 50, at 15–21 (explaining the ex ante auction model). As in our examples, Swanson and Baumol assume that the standard involves the choice of a single technology. *Cf.* Layne-Farrar et al., *supra* note 14, at 688 (extending the auction model to the case of multi-patent standards).

69. *See* Swanson & Baumol, *supra* note 50, at 21 (stating that ex ante competition can protect market from opportunism).

70. *See id.*

71. Layne-Farrar et al., *supra* note 14, at 686 (summarizing the Swanson & Baumol model).

72. Microsoft Corp. v. Motorola, Inc., No. C10-1823JLR, 2013 WL 2111217, at *14 (W.D. Wash. Apr. 25, 2013) (citing Microsoft's expert), *aff'd*, 795 F.3d 1024 (9th Cir. 2015); *see also id.* at *13 ("If alternatives available to the patented technology would have provided the same or similar technical contribution to the standard, the actual value provided by the patented technology is its incremental contribution. . . . Thus, comparison of the patented

It is this proposition, that an upper bound on a FRAND royalty is the incremental value of the patent as compared with the alternatives, including patented alternatives, before the standard was settled, that we challenge.

To see why, consider again our Scenario 1, where the alternative technologies are equally good and there are no recurring costs of licensing. In the auction to be part of the standard, the payoff to any unsuccessful patentee is zero, so if one patentee bids $1, another patentee would be willing to bid 99¢ rather than lose everything. In the end, the auction will bid the fee down to the patentee's marginal cost, which is zero in our scenario. Thus, in this scenario, the winning bid in the auction model would be $0.[73] By contrast, in Scenario 2, patentee *A* will capture the full value of the market, with a royalty of $100 per user. Patentee *A* will offer a royalty of $100 because it knows that is has no competition, and that offer will be accepted because each user strictly prefers to pay $100 than to do without the standardized WLAN technology entirely.[74] As Swanson and Baumol say, the patentee captures the difference in value between the best and the next best alternatives.[75] When there is only one candidate technology, the alternative is the prior technology—in this case, presumably a combination of cell phones and wired internet access—and the patentee can capture the full value of the standard. This result illustrates that under the auction model there is no general principle that the patentee cannot capture any part of the value of the standard. Indeed, under the auction model the patentee in Scenario 2 actually captures the *entire* value of the standardization.

technology to the alternatives that the SSO could have written into the standard is a consideration in determining a RAND royalty." (citing Microsoft's expert Kevin Murphy)).

73. *See* Layne-Farrar et al., *supra* note 14, at 690 (referring to Case 1); Swanson & Baumol, *supra* note 50, at 19 (assuming incremental c = 0).

74. *See* Layne-Farrar et al., *supra* note 14, at 690–91 (referring to Case 2). Layne-Farrar et al.'s Case 2 considers a two-patent standard with perfect competition ex ante for one of the components and no competition for the other, with the result that the patent holder for the component with no competition captures the entire value of the market. Our simplified scenario of a standard with a single patented technology is a special case in which there is perfect competition for one component because that component is not patented. Similarly, our scenario can be considered a special case of Layne-Farrar et al.'s Case 4, in which there is no competition for either of the components, in which case again the patentees will capture the entire value of the market. *See id.* at 691–92.

75. *See* Swanson & Baumol, *supra* note 50, at 19, 23.

In response, one might argue that, even if patentee *A* captures *the value of the standard* in Scenario 2, it does not capture *the value of standardization*, because all of the value of the standard is embodied in Patent *A*. In a slightly more complex example, however, the auction model will allow patentee *A* to capture the value of standardization. Suppose that the standard in question requires two patented technologies for its implementation, and there is perfect competition ex ante for one of the components and no competition for the other. That is, there is no substitute for technology *A*, but *X*, *Y*, and *Z* are perfect substitutes for one another. While *A* is worthless on its own, any pair (*A*, *X*), (*A*, *Y*) or (*A*, *Z*) will be equally effective. The result of an ex ante auction in that case is that patentee *A* will capture the entire value of the standardized market, while *X*, *Y*, or *Z*—whichever is selected—will get a royalty of zero.[76] This occurs even though one of *X*, *Y*, or *Z* is also necessary to the standard, such that *A* alone is worth much less prior to standardization. In this case, under the auction model *A* will capture the value of the standard even though that value is created by standardization.

These examples illustrate that, under the incremental ex ante approach, there is no general principle precluding the patentee from obtaining the value of the standard, or the value of standardization. Whether the patentee captures all or part of the value of standardization depends on the nature of the ex ante competition.[77] Indeed, "the value of standardization" has no independent definition under the auction model. It is defined only implicitly, as the difference between the value of the standard and the value to which the patentees are entitled under the auction model. The fundamental principle in the auction model is that the patentee is not entitled to more than the value of the invention, where, crucially, the value of the invention is defined by the state of competition in the ex ante auction.

But is that a sound principle? On the one hand, it is intuitively appealing to say that the patentee is not entitled to more than the value of its invention; however, some of that appeal is

76. *See* Layne-Farrar et al., *supra* note 14, at 690–91 (referring to Case 2).

77. Thus, if there are multiple technologies and there is imperfect competition for one of the technologies (that is, at least two technologies that could be used, but one is better than the other), the superior patentee captures a part of the value of standardization. *See id.* at 691 (referring to Case 3). The same is true when there is no competition.

lost under the technical definition provided by the auction model. We noted the ambiguity in the intuitive concept of the value of the invention in our Scenario 1, and the auction model resolved this ambiguity. But on the facts of Scenario 1, the value of the invention is zero under the implicit definition provided by auction model. This means that in Scenario 1, where there was in fact a fragmented market pre-standardization, in which patentee *A* charged $5 per user, after patentee *A* was "lucky" enough to have its technology selected as the standard the "fair and reasonable" royalty it would be entitled to charge would drop to zero. Thus, while it seems intuitive to say that a patentee should not be able to charge more than "the value of the invention," it does not seem quite so intuitive to say that "the value of the invention," and hence a fair royalty—which, after all, should be fair to the patentee as well as the licensee—should be zero in Scenario 1.

This counterintuitive result turns on the principle that the patentee's return should be constrained by ex ante competition. Though the principle also seems very intuitive, we will argue that it is unsound nonetheless, at least as embodied in the auction model. Ex ante competition is not desirable in and of itself, after all; it is desirable only to the extent that it promotes static and dynamic efficiency. We will argue that the auction model wrongly conflates network value appropriation and sunk costs holdup. An ex ante analysis is necessary to prevent sunk costs holdup, which has adverse efficiency implications. But the auction aspect of the model, which avoids network value appropriation, is unnecessary in terms of static efficiency and unsound in terms of dynamic efficiency.

B. STATIC EFFICIENCY

First off, it is important to recognize that *network value appropriation has no static efficiency implications*, or at least none beyond the implications of above marginal cost pricing that is inherent in the patent system. The payment from the user to the patentee is a mere transfer, as illustrated by the contrast between Scenario 1 and Scenario 2. In Scenario 2, whether bargaining between the patentee and the users results in a royalty of $10 per user, or $50 per user, or $100 per user, the users will not choose another technology, avoid investing altogether, or otherwise change their behavior, so long as the royalty is less than $100. True, the conclusion that no user will change her behavior is an artifact of our unrealistic assumption

that all the users have identical demand functions. More realistically, some users will be priced out of the market at higher royalty rates. But this is so whether there is a single patentee charging what the market will bear for its invention (Scenario 2), or a post-standardization patentee armed with an injunction (Scenario 1). The efficiency implications of allowing the successful patentee to capture some part of the market post-standardization are only those which are inherent in the above marginal cost pricing that is essential to the patent system.

In contrast, it is well understood that sunk costs holdup *does* have efficiency implications.[78] A patentee with an injunction can extract some portions of the user's sunk costs, in addition to the cost saving or profit boost accruing from the use of the invention as compared with the best alternative. While that immediate payment is only a transfer, the result of the payment is that an undertaking that would have been profitable for the user if it had licensed ex ante may be less profitable or even unprofitable if it has to license ex post. A transaction in which sunk costs holdup is a possibility is, ex ante, riskier than one in which it is not, all else being equal. The increased risk will cause the user to entirely avoid at least some transactions in which there is a possibility of sunk costs holdup occurring. In contrast to network value appropriation, with sunk costs holdup the amount the user is willing to pay ex ante is lower than the amount that the user would have been willing to pay ex post. It is that differential between ex post and ex ante value to the *user* that causes the user to inefficiently change its behavior.

To summarize, the static efficiency implications of sunk costs holdup and network value appropriation are very different, because with sunk costs holdup, the amount the user is willing to pay ex post is higher than it would have been willing to pay ex ante,[79] while with network value appropriation the amount that the user is willing to pay ex post is exactly the same as it would have been willing to pay ex ante.

Swanson and Baumol specifically identify the allocative inefficiency implications of sunk costs incurred by users,[80] but despite having identified the network effect as a mechanism giv-

78. *See, e.g.*, Farrell et al., *supra* note 17, at 615 (explaining that users may make inefficient investments to protect themselves from possible patent holdups).

79. *See supra* note 42.

80. *See* Swanson & Baumol, *supra* note 50, at 37.

ing rise to holdup, they never specifically identify its efficiency implications.[81] By omission, they imply that the same rationale applies to both phenomena, thus wrongly conflating sunk costs holdup and network value appropriation. Any royalty that is less than the incremental value to the user of the patented technology, excluding sunk costs, will satisfy allocative efficiency, at least within the broad bounds inherent in the above marginal cost pricing that is essential to the patent system.

This means that a royalty based on the auction model is not necessary for allocative efficiency. This may seem to be a strong claim, given that Layne-Farrar et al. described the auction model as "rooted in the concept of economic efficiency,"[82] and given that Swanson and Baumol assert that the outcome of the auction process and a license fee based on the efficient component pricing rule "will normally be the same."[83] However, efficient component pricing merely requires that the price that a patentee implicitly charges to itself for the use of its IP, which is the difference between the final product price and the incremental price of the other inputs, is equal to the price the patentee charges to licensees who are competing in the product market. This is, as Swanson and Baumol argue, a reasonable interpretation of the "nondiscriminatory" branch of the FRAND requirement.[84] The "efficient" aspect of ECPR[85] is that if this rule were not observed, a market might be captured by a manufacturer facing a lower IP cost (a licensee, or, more likely, the patentee itself) even though it had a higher incremental cost of other inputs, resulting in an inefficient use of non-IP resources. However, this in itself says nothing about marginal cost pricing of the IP. If the patentee charges itself an implicit price which is greater than its marginal cost of using the IP—in order to recoup its R&D investment, as per standard patent theory—there is nothing inefficient under ECPR about the patentee charging

81. Similarly, Farrell et al. correctly note that what we are referring to as sunk costs holdup is undesirable because it causes the user to inefficiently change its behavior. However, Farrell et al. then proceed to assert that what we refer to as network value appropriation exacerbates holdup, without identifying how it gives rise to either static or dynamic inefficiency. Farrell et al., *supra* note 17, at 603–16.

82. Layne-Farrar et al., *supra* note 14, at 685.

83. Swanson & Baumol, *supra* note 50, at 37–39; *see also* Layne-Farrar et al., *supra* note 14, at 687 (making this point about Swanson & Baumol's analysis).

84. Swanson & Baumol, *supra* note 50, at 37–39.

85. *Id.*

the same above marginal cost price to licensees, because the party with the lowest non-IP costs will still be able to capture the market.

After elaborating on the nondiscriminatory aspect of ECPR, with which we have no quarrel, Swanson and Baumol then assert that the ECPR-determined license fee and the royalty emerging from the auction process "will normally be the same."[86] But what they actually show is that the outcome of an auction process, namely incremental cost pricing, also satisfies the ECPR criterion.[87] They do not show that any price which satisfies ECPR will necessarily, or usually, be the outcome of an auction process. Thus they do not show that the outcome of the auction model and ECPR are "normally the same."[88] They show only that the outcome of the auction model is one possible royalty in the class of royalties that satisfies ECPR.

In summary, Swanson and Baumol never show that it is inefficient to allow the patentee to capture part of the value of standardization. Indeed, as we have seen, their auction model does allow the patentee to capture the value of standardization in some circumstances. Swanson and Baumol show that the auction pricing mechanism is *sufficient* to avoid inefficiencies associated with sunk costs and that it is nondiscriminatory, or efficient, in the ECPR sense.[89] But they do not show that the auction model is *necessary* to avoid inefficiencies associated with sunk costs or satisfy efficient component pricing. Moreover, while they identify network value appropriation as a mechanism giving rise to holdup,[90] they never specifically identify any inefficiencies associated with that mechanism. Nor are we aware of any other scholarship that purports to demonstrate, rather than merely assert, that allowing the patentee to

86. *Id.*

87. See *id.* at 38, where Swanson & Baumol argue that when faced with ample ex ante competition an IP owner cannot charge a price above marginal cost, "at least if the technology owner is effectively constrained ex post by pre-selection commitments." In effect, this assumption incorporates the auction pricing model into the ECPR formula, with the result that the ECPR formula reduces to an incremental cost royalty. However, the notion that the IP owner is constrained by pre-selection commitments does not rest on any principle of efficient component pricing, which requires only that the royalty charged by the patentee to others is the same as the implicit price charged to itself. If that assumption is relaxed, the link between ECPR and the auction model is broken.

88. *Id.*

89. *Id.*

90. *Id.*

capture part of the value of standardization results in static inefficiency.

C. INCENTIVES TO INVENT / DYNAMIC EFFICIENCY

Next, consider the effect of the auction model on patentee behavior. The first point to note is that the auction model is purely static; it does not consider dynamic effects on the incentive to innovate. This is what gives rise to the counterintuitive result that the patentee in Scenario 1 is entitled to nothing, despite having invented a valuable technology.

Swanson and Baumol acknowledge this, noting that "we would not expect 'reasonable' royalties to be equal to zero."[91] But in their model, royalties will exceed zero only because of what they describe as "a plethora of ongoing incremental costs" related to the licensing of IP, which, "in addition to involving costs of negotiation, contracting, accounting, monitoring, and auditing, also frequently involves the costs of instruction, training, and 24-hour assistance."[92] These costs are no more than the marginal costs of licensing and supporting, or at most improving, on the initial innovation. Thus, while Swanson and Baumol present this as a dynamic model, *it takes no account of the investment needed to induce the invention in the first place*. Their model explicitly assumes that "all investments in R&D by the patent holders already have been sunk and patent holders do not anticipate incurring any future costs as a consequence of licensing their patent."[93] They subsequently relax this assumption, but only by allowing for recurring costs, as just described.[94] A return for such ongoing costs alone is not sufficient to provide an incentive to invent the technology which is subject to the ex ante auction in the first place.[95] This is equally explicit in the extension by Layne-Farrar et al., which assumes

91. *Id.* at 22.

92. *Id.* at 22 & n.64.

93. *Id.* at 23. Indeed, Swanson & Baumol explicitly acknowledge that "[n]either the antitrust nor the patent laws deem it unreasonable for IP holders to seek to reap the returns that accrue *ex post* from the attainment of lawfully won monopoly or market power." *Id.* at 11. They go on to assert that in light of this limitation of antitrust and IP law, "private methods of control must be relied on to attempt to achieve this goal." *Id.* at 12. This argument fails to recognize that by allowing patentees to assert lawfully won market power, patent law provides the incentive to invent; it is a central feature of the patent system, not a shortcoming that needs to be rectified.

94. *Id.* at 19.

95. *See id.* at 22.

that the patented technologies exist at the time of the auction and explicitly states that the patentee's minimum return must exceed "the incremental cost of licensing its technology."[96] So, when there is perfect competition ex ante in the market for the patented invention, as in Scenario 1, "the equilibrium royalty rate of each component of the standard is given by the incremental cost of licensing."[97]

Thus the premise of the auction model, that a fair return to the patentee is equal to its marginal cost of licensing, is in conflict with the fundamental premise of the patent system, which is that the recovery of incremental costs alone is not sufficient to induce innovation. Swanson and Baumol's response to the objection that a reasonable royalty cannot be zero is to say that incremental costs of licensing normally exceed zero. But this misses the point. The (correct) intuition that a patentee's return cannot be zero reflects the premise of the patent system that marginal cost pricing is insufficient to induce innovation. A royalty of zero is simply the most obvious example of marginal cost pricing.[98] Swanson and Baumol address the intuition that a reasonable royalty should not be zero without addressing the substance underpinning that intuition, which is that marginal cost pricing does not provide sufficient incentive to in-

96. *See* Layne-Farrar et al., *supra* note 14, at 689–90.

97. *Id.* at 690. Similarly, Swanson & Baumol state, "As rival IP solutions come closer and closer to being perfect substitutes . . . the competitive royalty will approach *c*, the incremental cost of recurring innovation and licensing expenses." Swanson & Baumol, *supra* note 50, at 19.

Layne-Farrar et al. do note one criticism of the auction model, that "efficiency-based rules, which treat competitive market outcomes—even monopolistic ones—as optimal and ignore issues of equity, cannot be counted on to produce outcomes that are fair or reasonable." Layne-Farrar et al., *supra* note 14. Our critique of Swanson & Baumol is very different; our objection is that their efficiency-based approach considers only static efficiency, not dynamic efficiency.

Kieff & Layne-Farrar make essentially the same point we do, noting that "strict" interpretations of the incremental value rule, in which a patent holder is entitled only to the incremental value of its invention over the best patented alternative, "focus solely on the ex post problem," and ignores the need to provide an incentive to invent. F. Scott Kieff & Anne Layne-Farrar, *Incentive Effects from Different Approaches To Holdup Mitigation Surrounding Patent Remedies and Standard-Setting Organizations*, 9 J. COMP. L. & ECON. 1091, 1120 (2013).

98. Also, as a practical matter, it is far from clear that the patentee's incremental costs of licensing are substantially above zero in the context of software-implemented inventions that are common in standards.

vent.[99] In fact, there is no good response to the substantive point; the auction pricing model is simply inconsistent with the principle that a FRAND royalty should provide an adequate incentive to invent. This also resolves the fairness puzzle we noted earlier: the result that the patentee gets a zero royalty in Scenario 1 seems unfair because it is unfair. It is not only fair, but necessary, to allow the patentee to recover more than its marginal cost.

Finally, consider the effect of sunk costs holdup on patentee incentives. A disadvantage of the patent system from an innovation perspective is that by requiring above marginal cost pricing as a means of allowing the patentee to recover its sunk cost of invention, dissemination of the invention is restricted. The offsetting advantage is that the patent system gives the inventor high-powered incentives to pursue inventions which are socially useful, because the more valuable the invention to society, the larger the incentive.[100] The incentive is high-powered because it is the inventor's own money, not public funds, which are at risk. It follows from this that the reward to the patentee should not be greater than the value of the invention to society, or the incentive to invent will be too large.[101] If the patentee can extract some part of the user's sunk costs, in addition to the cost saving or profit increase provided by the patented technology, the incentive to invent will be greater than the costs saving or profit advantage provided by the invention, and the patent incentive will be too great.[102] Thus sunk

99. *See* Damien Geradin & Miguel Rato, *FRAND Commitments and EC Competition Law: A Reply to Philippe Chappatte*, 6 EUR. COMP. J. 129, 153 (2010) (making this point); Damien Geradin, *The Meaning of "Fair and Reasonable" in the Context of Third-Party Determination of FRAND Terms*, 21 GEO. MASON L. REV. 919, 948 (2014) (same); Sidak, *supra* note 14, at 972, 976–77 (same). Sidak, however, also appears to equate network value appropriation with holdup. *See* Sidak, *supra* note 14, at 1022 (arguing that patentees should be able to recover positive "holdup value"). We resist this characterization.

100. *See, e.g.*, Steven Shavell & Tanguy van Ypersele, *Rewards Versus Intellectual Property Rights*, 44 J.L. & ECON. 525, 530 (2001) (arguing that because a "patent effectively harnesses the private information of the innovator about the value of an innovation," patent incentives may be better than prizes "despite the deadweight loss due to monopoly pricing"); *see also* Benjamin N. Roin, *Intellectual Property Versus Prizes: Reframing the Debate*, 81 U. CHI. L. REV. 999, 1016 (2014) (reviewing the debate and arguing that patents may also allow inventors to resist expropriation by sub-optimal government rewards).

101. *See* Roin, *supra* note 100, at 1031–32.

102. *See id.*

costs holdup is dynamically inefficient as it results in excessive incentives to invent.

In summary, sunk costs holdup has negative dynamic effects on both user and patentee incentives; it induces users to avoid making socially valuable investments that might be subject to holdup, and it induces patentees to overinvest in patents in order to capture user's sunk costs. In contrast, network value appropriation has no negative static or dynamic effects on user incentives, and it has potentially positive dynamic effects on patentee incentives. For this reason, it is an error to treat network value and sunk costs holdup as being similar in nature and requiring the same response. Though both phenomena might be described as species of "holdup" because they both enable patentees to extract more ex post than they could have extracted ex ante, the efficiency implications of the two phenomena are completely different.

D. LEGAL OBJECTION: AUCTION VERSUS NEGOTIATION

This brings us to our legal objection to the auction model. The technical reason why the patentee in Scenario 1 ends up with a zero royalty under the auction model is that the patentee will necessarily be bid down to its *minimum* willingness to accept, namely its marginal cost, when it is bidding against another patentee with equally good technology. In contrast, the general legal rule is that damages in the form of a reasonable royalty are assessed by reference to a hypothetical *negotiation*, not an auction. The difference is that in a hypothetical negotiation the royalty is usually assumed to involve some split in the *difference* between the patentee's marginal cost and the user's maximum willingness to pay, so that some part of the surplus is captured by the patentee. A negotiation model—unlike the auction model—allows pricing above marginal cost, and that is what provides the incentive to innovate.

In response, one might argue that the auction model really is necessary from a dynamic perspective. The patent incentive must be commensurate with the value of the technology, and the value of the technology is the cost saving or profit increase *as compared with the best alternative*.[103] If the alternative is

103. *See, e.g.*, Grain Processing Corp. v. Am. Maize-Prods. Co., 185 F.3d 1341, 1349–50 (Fed. Cir. 1999); Farrell et al., *supra* note 17, at 611 ("Economic incentives generally work well when each person's or firm's reward for its actions is broadly commensurate with the incremental contribution of those ac-

just as good as the patented technology, then the appropriate reward to the patentee is zero. It is certainly not a principle of the patent system that the patentee should get a reward which covers its sunk cost of invention; on the contrary, what makes patent incentives high-powered is precisely that the inventor will lose money if the invention does not provide a sufficient advantage as compared to the alternatives.[104] The patentee must not be rewarded for re-inventing the wheel. On this argument, it seems that the incremental ex ante approach is sound because in Scenario 1 technology *A* is no better than technology *B*, *C*, *D*, and so on, and because *A* has not added any value over the alternatives, it should not be entitled to any reward.

In our view, this argument is entirely sound *if* the alternative is unpatented. In Scenario 1, if any of the alternative technologies are unpatented, then we entirely agree that a reasonable royalty for patentee *A* should be zero, for exactly the reasons just discussed. This is consistent with established law. Whether within the SEP context or otherwise, it is clear that the royalty cannot exceed the incremental value of the invention over an unpatented alternative, because the unpatented alternative determines the user's maximum willingness to pay.[105]

However, the same is not true if the alternatives are patented, either as a matter of policy or as a matter of law. In the standards context it is entirely plausible that in practice all the relevant technologies will be patented, precisely because of the incentive provided by the prospect of being included in the standard.[106] The same problem may also arise outside the standards context, and it is useful to consider how the problem should be treated generally, before returning to the SEP context.

Outside the SEP context, the law is not clear as to how a patented alternative should be treated; the limited case law in-

tions to total economic surplus.").

104. *See, e.g.*, Geradin, *supra* note 99, at 948.

105. *See* Grain Processing Corp. v. Am. Maize-Prods. Co., 893 F. Supp. 1386, 1390–93 (N.D. Ind. 1995), *rev'd on other grounds*, 108 F.3d 1392 (Fed. Cir. 1997).

106. *See, e.g.*, Anne Layne-Farrar, *Moving Past the SEP RAND Obsession: Some Thoughts on the Economic Implications of Unilateral Commitments and the Complexities of Patent Licensing*, 21 GEO. MASON L. REV. 1093, 1093–1110 (2014) (discussing the competition among patentees to have their technology included in the standard).

dicates that a patented alternative that is on the market should be considered available at the established patented price, which is normally above marginal cost.[107] In contrast, the auction model applied outside the SEP context implies that where the alternative is patented, the infringing user in the hypothetical negotiation should be imagined to play one patentee off against another until the patentee is haggled down to its minimum willingness to accept.

We are not aware of any literature providing a thorough theoretical analysis of this problem, and the solution is not evident. There is no accepted theory of the portion of the surplus that a single patentee should be able to claim as a matter of optimal incentives to innovate.[108] The problem of the optimal royalty to a patentee in the face of competition from a patented alternative is even more difficult, and we are not going to solve it here. It suffices to make three points, all of which turn on our general criticism that the auction model ignores the problem of the incentive to innovate which is at the heart of the patent system.

First, whatever the optimal royalty in the face of a patented alternative, the marginal cost pricing implied by the auction model is wrong from a dynamic perspective. The fact that two patentees develop equivalent technology at the same time does not mean that neither required the lure of a patent. Viagra and Cialis may be equally effective in treating erectile dysfunction, but that does not imply that they both would have been invent-

107. *See In re* Innovatio IP Ventures, LLC Patent Litig., No. 11 C 9308, 2013 WL 5593609, at *20 (N.D. Ill. Oct. 3, 2013) (stating that the court would consider patented alternatives, but "that they will not drive down the royalty in the hypothetical negotiation by as much as technology in the public domain").

108. While full appropriability of the social value of the invention by the patentee is sometimes suggested as the appropriate baseline, the optimal return is probably less than full appropriability for a variety of reasons. *See* Shavell & van Ypersele, *supra* note 100, at 535; *see also* YOCHAI BENKLER, THE WEALTH OF NETWORKS: HOW SOCIAL PRODUCTION TRANSFORMS MARKETS AND FREEDOM 37–38 (2009); Brett M. Frischmann & Mark A. Lemley, *Spillovers*, 107 COLUM. L. REV. 257, 268–71 (2007) (discussing several positive effects of spillovers); John M. Golden, *Principles for Patent Remedies*, 88 TEX. L. REV. 505, 529–31 (2010) (noting several negative effects of full appropriability); Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J. ECON. PERSP. 29, 31 (1991) (discussing two major downsides to using full social value as baseline); Carl Shapiro, *Patent Reform: Aligning Reward and Contribution*, 8 INNOVATION POL'Y & ECON. 111, 114–17 (highlighting the negative effects of overrewarding patent holders).

ed if pharmaceutical patents were not available. The auction model implies that the reasonable royalty for a user of Viagra is a few pennies, because in an auction a user could play Pfizer against Lilly to drive the royalty down to marginal cost. But when both alternatives are subject to a valid patent it must be assumed that the patentees would not have invented their technology unless they anticipated getting more than marginal cost.[109] If both patentees receive a zero royalty, or close to it, whenever two or more equivalent technologies are invented, then the expected return to either will be zero, which is clearly insufficient to induce the invention in the first place.

Second, the patent system does not turn on the theoretical return to the patentee in a bargaining model, or on the theoretically optimal return to the patentee from an incentive perspective. Rather, the amount that patentees have actually been able to extract in real-world negotiations are the primary drivers of the patent system's incentives. By the same token, courts have rejected reliance on theoretical models that are not adequately tied to the facts of the case.[110] At least in the absence of a generally accepted theoretical optimum, the benchmark return should be given by comparable actual negotiations. By the same token, in the absence of evidence that, in the real world, competition among competing patentees regularly results in users bargaining both patentees down to their marginal cost, a reasonable royalty should allow a patentee competing with a patented alternative to recover some part of the surplus due to its invention.

Further, there is no principled difference between the SEP context and the general patent context which justifies an auction model in the former and a negotiation model in the latter. The image of multiple patentees with different technologies competing against one another for the prize of being made part of the standard makes a model in which competition forces the patentee down to its marginal cost seem plausible in the SEP context. But even outside that context, when we are consider-

109. This accepts the substantive law as sound, and in particular that the nonobviousness standard ensures that patents are granted only for inventions which required the lure of a patent. We doubt this is true in practice, but we consider it to be the appropriate assumption in the remedial context. *See* Siebrasse & Cotter, *supra* note 15, at 14 n.55.

110. *See* Virnetx, Inc. v. Cisco Sys., Inc., 767 F.3d 1308, 1331–34 (Fed. Cir. 2014) (rejecting an expert's use of the Nash Bargaining Solution); Uniloc USA, Inc. v. Microsoft Corp., 632 F.3d 1292, 1315 (Fed. Cir. 2011) (rejecting the twenty-five percent rule of thumb).

ing one patented technology that is substantially superior to an unpatented alternative, it is still possible in principle that the patentee will be haggled down to its incremental cost. Nevertheless, the law generally does not assume that the patentee always will be haggled down to its minimum willingness to accept. For this reason, the auction model of SEPs is inconsistent with the general law of reasonable royalty damages.[111]

E. SHAPLEY PRICING

Up to this point, we have argued that the auction model should be rejected as being unnecessary for static efficiency and unsound in terms of providing adequate incentives to invent. But are there any better alternatives?

One alternative that remedies some of the defects of the auction model is Shapley pricing.[112] As described by Layne-Farrar et al., the Shapley value in the standard setting context can be thought of as the outcome of a process in which:

> [T]he patent owners arrive at the SSO in random order each with her patent in her pocket, with all possible arrival sequences equally likely. Now suppose that in each sequence, each patent owner receives the amount by which her patent increases the value of the best standard that can be built from the patents that are already at the SSO when she arrives. That is, if the set of patents S is at the SSO when patent j arrives, *j's* owner receives the incremental value $v(S \cup j) - v(S)$. The Shapley value gives j the average of such contributions over all possible arrival sequences—each patent thus receives the average (over arrival sequences) of its marginal contribution.[113]

111. Another difficulty with the auction model is that *expected* marginal contribution may be different from the *actual* marginal contribution. For example, as explained in *Microsoft*, support for video interlacing is part of the H.264 standard. Video interlacing was important for older technology but is now largely obsolete and is required largely as legacy support. Microsoft Corp. v. Motorola, Inc., No. C10-1823JLR, 2013 WL 2111217, at *21–22, *24 (W.D. Wash. Apr. 25, 2013), *aff'd*, 795 F.3d 1024 (9th Cir. 2015). Suppose, however, that at the time the standard was developed, no one anticipated the changeover from interlacing to progressive video. Support for interlacing might have been considered valuable ex ante, yet, in fact, it is now used by few users. Under the incremental ex ante approach, a party with patents on key interlacing technology might command a high royalty, even though the actual value of that technology to users is low. By contrast, under the contingent ex ante approach that we describe in Part III, royalties will reflect the actual value of the technology to the user.

112. Named after Lloyd S. Shapley, who introduced the concept. L.S. Shapley, *A Value for n-Person Games*, *in* 2 CONTRIBUTIONS TO THE THEORY OF GAMES 307 (H.W. Kuhn & A.W. Tucker eds., 1953).

113. Layne-Farrar et al., *supra* note 14, at 695; *see, e.g.*, H.P. Young, *Individual Contribution and Just Compensation*, *in* THE SHAPLEY VALUE: ESSAYS

That is, the return to any patentee is the expected amount that its patent would contribute to the total value of the standard. So, in our Scenario 1, each of the ten patentees with equally good WLAN technology would be entitled to one tenth of the value of the standard, or $5 per user. The intuition is that if *A* were the first technology to arrive and was therefore selected as the standard, it would then able to extract a royalty of $50 from each user. If *B* arrived next, it would add nothing to the value of the standard, since *A* and *B* are purely alternatives, so it would receive zero, as would all the others except *A*. But if *B* happened to arrive first, it would receive $50, and *A* would receive nothing, as would all the others except *B*. The average over these scenarios is the Shapley value. We will refer to the approach proposed by Layne-Farrar et al. as "ex ante Shapley pricing" because each patent owner whose technology might have been included in the standard is entitled to a share, regardless of whether its particular technology is actually chosen.[114]

While Layne-Farrar et al. present Swanson and Baumol's auction models as efficiency-based, and Shapley pricing as "just,"[115] this is not entirely fair to Shapley pricing, which is more efficient than auction pricing. It is true that Shapley value pricing is fair in an intuitive sense; for example, all the technologies in Scenario 1 are equally good, and with Shapley pricing, all patentees will get the same royalty.

But Shapley pricing is also efficient. Under Shapley pricing the patentees do share in the value of standardization, as it is an explicit premise of the Shapley approach that the patentees are entitled to the same value that would be available to a single patentee holding patents to all the relevant technologies.[116]

IN HONOR OF LLOYD S. SHAPLEY 267 (Alvin E. Roth ed., 1988) [hereinafter THE SHAPLEY VALUE] (providing further discussion); *see also* MARTIN J. OSBORNE & ARIEL RUBINSTEIN, A COURSE IN GAME THEORY 291 (1994) (providing a similar explanation). To date, however, Shapley pricing does not appear to have received any attention in the case law.

114. *See* Layne-Farrar et al., *supra* note 14, at 695–96 (noting that in their approach to Shapley pricing, patents that are not part of the ultimate standard will nonetheless receive non-zero value).

115. *Id.* at 693.

116. *See id.* at 694 ("The total value of the standard is distributed among all patents; nothing is left over."); THE SHAPLEY VALUE, *supra* note 113, at 269 (noting that a premise of Shapley value is that the output is "fully distributed"). The value of the standard is implicitly the amount that can actually be charged by the standard owner, not the social value. So while the premise, as described by Layne-Farrar et al., is that "[t]he total value of the standard is

But as we have seen, this in itself does not have any adverse implications for allocative efficiency. In terms of dynamic efficiency, the Shapley approach is in principle superior to the auction model. Because the value shared by the patentees is the same as the value that could have been captured by a single patentee, the expected return to potential inventors under Shapley pricing is the same as that facing a single patentee charging what the market can bear. As we have seen, this may not be strictly optimal, but it is the appropriate benchmark.

Shapley pricing can also be implemented to avoid inefficiencies due to sunk costs holdup by defining the value of the standard appropriately. It is established law that a reasonable royalty to a single patentee must be assumed to be negotiated ex ante, in order to avoid sunk costs holdup; by extension, the value that the patentees share under Shapley pricing is that value that could be extracted by a single patentee holding all the relevant patents but prior to the users incurring any sunk costs.[117] If we define the value of the standard in this way, sunk costs holdup is avoided, and Shapley pricing is just as good as the auction model in terms of allocative efficiency.[118]

Thus Shapley pricing is both fair and more efficient than auction pricing. Ex ante Shapley pricing as described by Layne-Farrar et al. does have one major drawback, however, which means that in practice it will not be adequate from a dynamic perspective. It achieves fairness by awarding a royalty to all

distributed among all patents," this refers to the value of the standard that can be extracted in licensing, not the overall social value. Layne-Farrar et al., *supra* note 14, at 694. The authors also state that Shapley pricing approach "ignore[s] any market power that being included in a standard might bestow," but they go on to explain that "[t]he Shapley value method of distributing rents bases payoffs on ex ante marginal contributions, so even IP that is not part of the 'winning' standard receives some payoff, as long as its average marginal contribution to some collections of patents is positive." *Id.* at 701. Thus, they do not dispute that the patentees as a whole capture some part of the value of standardization, as does the particular patentee which is selected to be part of the standard, which is our point. Shapley pricing ignores the value of being included in the standard only in the sense that patentees which are not included in the standard will also share in the value of standardization.

117. We consider this to be an uncontroversial clarification of Shapley pricing. The Shapley model, even as explained by Layne-Farrar et al., is not explicit as to how the value of the standard is to be determined, as Shapley pricing is primarily concerned with how to split that value.

118. Because Shapley pricing results in above marginal cost pricing, some users will be priced out of the market, but as discussed above, this is inherent in the patent system generally.

patentees whose technology might potentially have contributed to the standard, even if the technology was not actually selected. As noted, in our example this means that all ten patentees would be entitled to a royalty, even though only one was actually selected. The difficulty with using ex ante Shapley pricing as the FRAND royalty is that as a matter of law only the patentee who is actually selected is entitled to a royalty, because none of the others will have their patent infringed. In Scenario 1, if *A* is selected, and is entitled to a royalty based on its ex ante Shapley value, it will only get a royalty of $5, which means that the expected return to all patentees will be only one-tenth of what a single patentee would have received. In principle, the patentees collectively should be entitled to receive the same amount as a single patentee. But in the real world, only a patentee whose patent is actually infringed will be entitled to a recovery, so in practice the actual aggregate return to the patentees would be substantially less than what would be available to a single patentee. This, in turn, implies that the expected return to an inventor contemplating an investment in a standardized technology would be correspondingly inadequate.

III. THE INCREMENTAL CONTRIBUTION OF THE PATENT TO THE VALUE OF THE STANDARD TO THE USER

In this Part, we argue for our alternative approach to calculating FRAND royalties, under which the royalty reflects the incremental contribution of the patent in suit to the value of the standard. As noted in the Introduction, this approach combines two elements which we view as mutually reinforcing: first, a contingent ex ante framework which attempts to estimate the bargain that reasonable parties would have struck prior to incurring sunk costs, but with full knowledge of all relevant information that is revealed ex post (including the patent's inclusion in the chosen standard); and second, ex post Shapley pricing, which allocates the aggregate royalties payable for the manufacture, sale, or use of standard-compliant products in proportion to each patent's ex post marginal contribution to the value of those products. Section A explains why the contingent ex ante approach is preferable to the Swanson and Baumol incremental ex ante approach, and Section B extends the framework to multiple SEPs. Section C then introduces ex post Shapley pricing, and Section D discusses the practical implications of our proposal.

A. THE CONTINGENT EX ANTE APPROACH

We propose that a better approach for setting FRAND royalties is to posit a contingent ex ante hypothetical negotiation, coupled with what we will call "ex post" Shapley pricing.[119] As in Swanson and Baumol's auction model, this approach assumes that royalties are set ex ante, that is, before users have incurred any sunk costs, and thus avoids the problem of sunk costs holdup. Our model differs from Swanson and Baumol's, however, in that it is a negotiation model rather than an auction model. This means that the patentee and the user split the difference between the user's maximum willingness to pay and the patentee's minimum willingness to accept, in contrast to the auction model in which the patentee is bid down to its minimum. Moreover, the characteristic feature of the contingent ex ante approach is that, while the hypothetical negotiation takes place ex ante, the parties are assumed to have all ex post information; in particular, the parties are assumed to know which technology was selected as the standard.[120] Put another way, the hypothetical negotiation takes place ex ante, but it is contingent on ex post information. This feature ensures an adequate return to the patentees. The royalties are then apportioned among the patentees according to Shapley pricing. However, rather than apportioning the royalties among all those patentees who *might* have been selected for the standard, as in the Shapley pricing model discussed by Layne-Farrar et al., our approach apportions the royalties only among patents that ac-

119. The contingent ex ante model was originally proposed by Mario Mariniello. Mario Mariniello, *Fair, Reasonable and Non-Discriminatory (FRAND) Terms: A Challenge for Competition Authorities*, 7 J. COMP. L. & ECON. 523, 526 (2011) ("[T]he licensing terms offered after the adoption of the standard (ex-post) should not be worse than those which the patent holder would have committed to ex-ante in the context of a standard setting contest conditional on the information that is available ex-post."). We further developed it in a recent article. *See* Siebrasse & Cotter, *supra* note 15.

120. More precisely, the fundamental principle is that the parties negotiate with ex post knowledge, which, in an infringement action, normally means that they will know whether the patents in question are essential. Note, however, that in *Microsoft*, whether the patents were in fact essential had not been established, because the action was not one for infringement, but rather for breach of contract premised on Motorola's alleged failure to abide by its FRAND commitment. The court correctly held that, under these circumstances, a reasonable rate would be discounted to allow for the probability that the patents at issue were not in fact essential to the standard. *See* Microsoft v. Motorola, No. C10-1823JLR, 2013 WL 2111217, at *53 (W.D. Wash. Apr. 25, 2013), *aff'd*, 795 F.3d 1024 (9th Cir. 2015).

tually *are* selected for inclusion in the standard. For this reason, we refer to it as ex post Shapley pricing, in contrast with the ex ante Shapley pricing described by Layne-Farrar et al. Ex post Shapley pricing implements the apportionment principle.

The simplest way to understand our approach is to imagine a three-step process. In the first step, the SSO decides on the standard, including the patented technologies to be incorporated into the standard. In contrast to the incremental ex ante approach, users have no direct input at this stage (though the interests of the users will be taken into account by the SSO, which attempts to develop a standard that the users will find valuable). In the second stage, the SSO negotiates a royalty for the standard with the users before the users have invested any sunk costs in reliance on the standard. In the negotiation process, the users do not have the option of adopting another standard incorporating different patented technology, but if a standard can be adopted with unpatented technology, that option can be taken into account. This means that the users cannot use the threat of switching to a standard based on patented technology B as bargaining leverage, though they can use the threat of switching to a non-standard technology B, or to a standard based on unpatented technology. In the third stage, after the royalty is negotiated, the SSO divides the royalty among the successful patentees by applying Shapley pricing to the technologies which were actually selected. (Note that this three-stage process does not strictly reflect our approach—some technical refinements are discussed in Appendix B—but it illustrates its main points. Neither this model nor the more detailed model set out in the Appendix are intended to describe how we think a real world royalty setting process should work. Rather, they are conceptual benchmarks for assessing a FRAND royalty, in the same spirit as Swanson & Baumol's model.)

Two points about the contingent ex ante approach deserve emphasis. First, because the negotiation takes place before the standard is adopted, the patentees whose technologies are adopted cannot capture any of the users' sunk costs. This avoids any inefficiencies associated with sunk costs holdup. Second, the expected returns to inventors seeking to develop technology that will become part of the standard will be the same as the expected return to a single patentee seeking to develop that technology in the absence of competition. In other words, it does not matter whether the standard develops

through a formal standard setting process or emerges as a de facto standard; the reasonable royalty will be the same in either case. As explained in the context of Shapley pricing, we view this as the appropriate benchmark in terms of providing an incentive to invent. Conversely, from the perspective of the user, the contingent ex ante approach is neutral amongst the various possible reasons why the technology at issue is valuable to the user.

Thus, to return to our motivating examples, the result of the contingent ex ante hypothetical negotiation in Scenario 1 would be exactly the same as the result of an actual negotiation in Scenario 2B. In Scenario 2B, the users are willing to pay up to $100 to use technology *A*, because it is a standard (de facto). Under the contingent ex ante approach to Scenario 1, the users would likewise be willing to pay up to $100 to use technology *A*, because it is a standard (as a result of the formal selection process). In both Scenarios 1 and 2B, the patentee's minimum willingness to accept is its marginal cost (which is zero in our examples) and each user's next-best alternative is a non-standard WLAN technology worth $10 (which each can license for $5).[121] If the parties have the same bargaining power in both Scenarios, the royalty will be exactly the same in either case.[122] The exact share that will be captured by the patentee in a bargaining model is indeterminate, but in our view that is not a flaw in our model.[123] It is a reflection of the reality that there is no good descriptive model of the amount patentees actually receive in licensing negotiations. As discussed above, a full theo-

121. In Scenario 1, that alternative would be one of the technologies that might have been, but was not, included in the standard, while in Scenario 2B it is one of the technologies that did not become a de facto standard because it emerged after *A*.

122. In Scenario 2, where there is only one WLAN technology, the users' alternative is to use the pre-WLAN alternatives, such as telephones and wired internet, which are defined to be worth zero, and so on a standard Nash Bargaining Solution the patentee's royalty would be slightly higher than in Scenario 1. Nonetheless, the principle is that the royalty does not depend on how the standard emerges; Scenario 1 is functionally different from Scenario 2 in terms of the alternatives available to the users, but functionally the same as Scenario 2B. We should emphasize that a Nash Bargaining Model is not a part of the contingent ex ante approach. Our basic point is that it is a bargaining model, as opposed to an auction model, which means that the patentee and the users will split the surplus.

123. For a contrary view, see Roger D. Blair & Thomas Knight, *Problems in Sharing the Surplus*, 22 TEX. INTELL. PROP. L.J. 95 (2013) (objecting to bargaining models in the SEP context on the basis that the split in the surplus is arbitrary and an arbitrary royalty cannot be reasonable).

retical bargaining model would incorporate considerations of the optimal return to patentees from an incentive perspective. The case law, on the other hand, attempts to answer this question from an empirical perspective, by looking for the returns on comparable licenses. For our purposes, it is enough to say that a bargaining model, not an auction model, is appropriate in the SEP context, just as it is appropriate in the context of reasonable royalty damages generally.

Before turning to the question of apportioning the royalty among the many patented technologies making up the standard, we will consider some objections to our model that can be assessed in the context of the simple single technology standard. The most important of these is that, while the patentee whose technology is adopted cannot capture any of the users' sunk costs, it is able to capture some substantial part of the value of standardization. This seems contrary to the principle that the patentee is entitled to capture the value of its technology, but not the value of standardization. We have two responses to this objection, or more precisely two different ways of framing the same response.

One response is to say that, if the principle that the patentee is not entitled to capture any of the value of standardization is understood as meaning that the royalty available to the patentee should be capped by its incremental ex ante value as in the auction model, then that principle is simply wrong. As discussed in our critique of the auction model in Part II,[124] the incremental ex ante model does not provide an adequate incentive to invent, whereas the contingent ex ante approach provides an appropriate incentive to invent without any allocative inefficiency (apart from the possibility of some users being priced out of the market, which is an implication of the patent system generally).

But we need not reject the principle that the patentee is entitled to capture only the value of the technology, so long as that value is properly defined. The cases establishing this principle do not provide a precise definition of "the value of the technology," perhaps on the assumption that the term is self-evident. But as discussed above, even in the very simple example illustrated by Scenario 1 it is not at all intuitive what constitutes the value of the technology; is it the $500 that patentee *A* was in fact receiving annually prior to standardization, or the

124. *See supra* notes 98–99 and accompanying text.

consumer surplus of its customers ($1000 in our example), or the full value of the market to all patentees prior to standardization ($5000), or even the full social prior to standardization ($10,000)? Or it is zero, as Swanson and Baumol's auction model would have it? Certainly it seems strongly counterintuitive to say that the value of the technology was zero, given that the patent was actually licensed for $500 before standardization, and the value of the market dependent on the technology is $100,000.

In our view, "the value of the technology" is simply the value of the technology to users; or more precisely, the value of the functionality provided by the patented technology, as compared with the next best unpatented alternative, excluding any amount that can be extracted because of sunk costs expended by the user in reliance on that technology.[125] It is the technology itself that is being valued, not the patent.[126] This is why the contingent ex ante approach gives the same result in Scenarios 1 and 2. The value of WLAN to the user is the same whether the technology emerges from a formal standard setting process or a de facto process; the value of WLAN to the users is the same whether there is only one technology capable of providing that functionality, or many technologies.

Further, our analysis suggests that there is no such thing as "the value of standardization" distinct from the value of the technology. Consider, for example, a communications technology that is valueless unless at least two people are using it. Should we say that the value of the first telephone was zero because it was useless until there were two? But when there were two telephones, was the value of those telephones attributable to the telephone technology or to the fact that they were shared? To be sure, the value of a communications technology does rise more than proportionately as the number of users increases (which is what gives rise to network effects). But it is conceptually impossible to separate the contribution of the technology and the contribution of the network effects, unless we say that the value of the technology is the value when there

125. Put another way, the key meaning of the "value of the technology" is that the patentee should not be able to capture any part of the users' sunk cost. As we have noted, standardization is often accompanied by sunk costs, and in our view the principle that the patentee cannot capture any of the value of standardization is sound to the extent that it means that the patentee cannot capture any of the users' sunk costs.

126. *See* Taylor, *supra* note 16.

are no network effects at all—which is to say, zero. Other than that, we cannot say that the natural value of the technology is the value of the network when there are two users, or 100 or 1,000,000; the numbers are arbitrary. Moreover, while it may seem natural to say that the value of standardization is the value that arises after the standard is adopted, this understanding is arbitrary too, because it suggests that the value of the technology is different depending on whether the standard happened to be adopted when there were 100 users or 1,000,000. But the particular time of standardization is happenstance. If a patentee cannot capture any more value than inhered in the technology prior to adoption of the standard, then all patentees would want to delay the standardization process in order to maximize the returns to patentees.[127] This is clearly undesirable.

More generally, our analysis treats all sources of value neutrally. Whether the value of the technology is due to network effects, to effects which scale linearly (such as per-unit production cost savings), or to idiosyncratic factors does not affect the royalty the user should pay. This principle of value neutrality is sound. To illustrate, suppose a patented invention which causes LEDs implanted in running shoes to flash synchronously with dance music is worth $100 million to users because it becomes a fashion craze after being featured in a music video. It is uncontroversial that the patentee in that case is entitled to capture a share of the full $100 million. Now suppose that another invention enables a substantial increase in WLAN network speeds and is also worth $100 million to users after it is adopted as a standard. Suppose further that the value arising on standardization due to network effects, however that might be defined, is $90 million. If the patentee in the second example is entitled only to a share of the $10 million, on the view that it is not entitled to capture any value of standardization, there will be a substantially greater incentive to invent technologies like flashing shoes rather than enhanced WLAN, even though the social value is the same in either case. In our view, the patent system should not discriminate between inventions depending on the source of their value to users, but if

127. If the patentees cannot capture any of the value arising ex post, collectively they would prefer to have the standard arise de facto. No individual patentee would be sure that its technology would prevail, but the aggregate return would be higher if the standard developed later and thus the expected value to any patentee would be increased by delay.

there is an argument to be made for discrimination on that basis, surely network effects are not a source of value that should be particularly *dis*favored.

In our approach, by contrast, the value of the technology is simply equal to its value to the users, whether the technology happens to be one in which the value grows more or less linearly with the number of users, as with pharmaceuticals, or disproportionately with the number of users, as with communications technology. (Indeed, there is no sharp distinction between technologies which show network effects and those which do not, as many, perhaps most technologies display network effects to some degree.)[128] And while the users cannot play off one patented technology against another, they can threaten to go to an unpatented standard as leverage in the bargaining process. This means that the value of the technology is capped by the difference in the value to the user and the value of the best unpatented alternative. For example, suppose that as in Scenario 1, the market is mature but fragmented. There are nine firms that have developed and patented WLAN technology, *A*, *B*, . . . *I*, but the tenth technology *J*, is unpatented. These technologies are all equally good. Even if the SSO selected technology *A* as the standard, in the ex ante negotiation the users would be able to threaten to adopt the unpatented technology *J*, which means that *A* will get a royalty of zero. This is intuitively sound, given that *A* is no better than the unpatented alternative. More generally, the value of the technology that is adopted as the standard is no more than the value as compared with the best unpatented alternative standard.

Consequently, under our approach *a FRAND royalty is treated in exactly the same manner as any other reasonable royalty*.[129] Our concept of the value of the technology in the FRAND context is exactly the same as the standard definition of the value of the technology outside the FRAND context, which is to say it is the difference between the value to the user of the technology and the next best unpatented alternative.[130] Our ap-

128. For example, a particular car model becomes more valuable as more people own it, because parts are more easily available; a drug will become more valuable as more people take it because prescribing physicians will become more familiar with its effects; and so on.

129. *See* note 119 and accompanying text. In this respect we agree with Contreras & Gilbert, *supra* note 55.

130. *See, e.g.*, Grain Processing Corp. v. Am. Maize-Prods. Co., 185 F.3d 1341, 1349–50 (Fed. Cir. 1999).

proach therefore can be directly applied to any reasonable royalty scenario, and it simply reduces to a simpler model as the circumstances require.

A second possible objection to our contingent ex ante bargaining model is that it is unfair, inasmuch as all of the ten patentees had exactly equivalent technologies, and *A*'s selection was more or less arbitrary. In our model, *A* is the only patentee to share in the surplus; the others get no return on their inventions, which were just as valuable as *A*'s except for the happenstance of not being chosen. This point seems to underpin the intuition that a patentee should only be entitled to the value of its invention and not the value of standardization.[131]

We concede that, by awarding the entire value of standardization to *A*, even though *A* was selected arbitrarily, the contingent ex ante approach might seem to abandon the fairness that is an attractive feature of ex ante Shapley pricing. The difference between ex ante Shapley pricing and the contingent ex ante approach in this respect is that under the contingent ex ante approach the entire expected return will be realized by the patentee whose technology is selected, whereas under ex ante Shapley pricing it would be split between the successful patentee and unsuccessful patentees who will never be able to bring a claim. Even so, the contingent ex ante approach is fair to patentees on average (if not in individual cases), and it is certainly more fair to patentees than Swanson and Baumol's auction model. And our approach is no more unfair than the patent system generally. In our Scenario 2, for example, technology *A* captured the entire market because it was developed first. If *B* through *J* were developing their inventions at the same time, and just happened to be slightly later to market, the incremental value of *A*'s contribution is only the slightly earlier date of development, and not the entire value of the WLAN market. Yet *A* will uncontroversially be able to capture the entire value of the market,[132] simply by virtue of hav-

131. *See, e.g.*, Layne-Farrar et al., *supra* note 14, at 685 ("Common sense suggests that it cannot be 'fair,' 'reasonable,' or 'non-discriminatory' to offer the holder of easily substitutable patents the same compensation as the holder of a critical, irreplaceable patented technology supporting the same standard."). For other objections, see George S. Cary et al., *The Case for Antitrust Law To Police the Patent Holdup Problem in Standard Setting*, 77 ANTITRUST L.J. 913, 919–20 (2011) (arguing, among other things, that ex post events are unanticipated and therefore not relevant to incentives). We address this issue in Siebrasse & Cotter, *supra* note 15, at 29–30.

132. By this we mean the $50,000, not the full social value of $100,000.

ing been first. When a de facto standard emerges because of the first-to-market advantage, the advantage gained by being incrementally first is almost as unfair as the advantage gained by being selected by an SSO, yet this is not thought to be an objection to the ordinary operation of the patent system.

Two further issues deserve comment. First, under our approach it is possible that the return to any individual patentee may be less than the cost of the invention, even if the value of the WLAN technology is greater than the aggregate cost of invention, simply because a patentee whose invention is not incorporated into the standard may not receive any royalty at all. But we do not view this as an objection to our approach; rather, it is simply a reflection of the patent race problem that may arise in any area of patent law.[133] In many fields, such as pharmaceuticals, roughly similar solutions to the same problem may be patented at approximately the same time, and consequently they will share a market that otherwise might have gone to just one of them. The problem is exactly the same whether there are network effects, so that one of the alternatives takes a large share of the market and the others get none, or when there are no network effects, so that all the alternatives take a smaller share of the overall market. In either case, the expected return to the patentees is less than it would be in the absence of simultaneous invention, and in either case the simultaneous invention arises for the same reason, namely that many different inventors perceive the same need and provide an innovative solution. While this may well be a problem for innovation, it is not one which a theory of SEP royalties needs to address. In any event, our contingent ex ante approach, under which the patentee gets some part of the value of standardization, is surely better from this perspective than the auction approach, in which even the winning patentee gets nothing.

Second, unlike the auction model, the contingent ex ante approach does not provide any precise number for the reason-

133. In principle, a patent race could dissipate the entire patentee surplus, though in reality the effects of patent races may be more complex. *See* Mark A. Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 749–60 (2012) (discussing the literature and arguing that patent races "may have gotten a bad rap"). More generally, the contingent ex ante model does not guarantee the patentee a sufficient return to cover its costs of invention. We do not view this as a shortcoming of the approach; this is a characteristic of reasonable royalty damages generally and it is this fact which makes the patent incentive high-powered.

able royalty, even in theory. The hypothetical negotiation splits the surplus between the parties and thus leaves the outcome of the negotiation to the theoretical black box of bargaining power (or, in practice, to any evidence of bargaining power and comparable licenses in the particular field). Again, though, we do not view this as a shortcoming of the model. There is no good general model of the optimal return to a patentee, and our model, like the hypothetical negotiation in reasonable royalties generally, is agnostic on that point. This agnosticism is preferable to the auction model, which does provide a clear outcome, but one which is clearly inefficient from a dynamic perspective. And because the contingent ex ante model is applicable to reasonable royalties generally, if a general model of optimal royalties ever were to become accepted, under our model it would be directly applicable in the SEP context as well.

B. EXTENSION TO MULTIPLE SEPS

Two additional issues arise when a standard requires multiple patents for its implementation. One is the well-known problem of royalty stacking, which requires that the overall royalty for the standard not be excessive.[134] The second is how to allocate royalties among the essential patents, a matter we referred to above as the apportionment problem.[135] Apropos of this second issue, the emerging FRAND case law recognizes that "a patent that is extremely important and central to the standard would reasonably command a higher royalty rate than a less important patent."[136] In this Section, we show that the contingent ex ante approach addresses the problem of royalty stacking, and when supplemented with ex post Shapley pricing, it also resolves the apportionment problem. In contrast, the incremental ex ante approach, as it turns out, is inconsistent with the proportionality principle.

Extending the contingent ex ante approach to multiple patents is straightforward. In our three-step approach, by way of illustration, the user is assumed to bargain with the SSO for the right to use the standard. But since the user values the standard as a whole rather than the individual patents, this step is the same whether the standard requires one patent or

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

135. *See supra* notes 7, 20 and accompanying text.

136. Microsoft v. Motorola, No. C10-1823JLR, 2013 WL 2111217, at *20 (W.D. Wash. Apr. 25, 2013), *aff'd*, 795 F.3d 1024 (9th Cir. 2015).

many. In other words, whether the functionality is implemented by one patent or many is irrelevant to the value of that technology to the user, and it is therefore irrelevant to the royalty that will be paid by the user in the negotiations with the SSO. This in itself eliminates the problem of royalty stacking, both in terms of Cournot complements[137] and in the more general sense of excessive royalties arising from multiple licenses. Under the contingent ex ante approach, the patentees jointly will receive, and the user will pay, exactly the same amount as if the standard was implemented by a single technology held by a single patentee.

More generally, the royalty that a single patentee who had developed all the relevant technology would receive as the result of a contingent ex ante negotiation is the appropriate benchmark for a FRAND royalty for a standard involving multiple patentees. The value of the functionality to the user is the same whether that functionality is implemented by one patented technology or by multiple patented technologies. The total return to the patentees should also be the same either way: otherwise, patentees would have an incentive to implement the standard in a way that requires multiple technologies rather than one, in order to claim a larger share of the value of the functionality. Consequently, we take it as a fundamental principle that the overall royalty should not depend on the number of patents.

The equivalency with a negotiation with a single patentee also satisfies both the principle that the royalty should provide an adequate incentive to invent (i.e., that the royalty should be commensurate with the value of the invention) and that it should balance widespread adoption of the standard against a reasonable return to the patentees.[138] Under the contingent ex ante approach, the total royalties payable for use of any standard are proportionate to the standard's social value. Moreover, the total royalty paid by the user will be the same whether the standard is a de facto standard with a single patent being held by a single patentee, multiple patents held by a single patentee, or a standard set by an SSO with multiple patentees. The reward to the patentees as a group—whether that group consists of one or many individuals—depends only on the value of the standard to the user. This ensures that the reward for

137. *See supra* note 5.

138. *See supra* notes 10–11 and accompanying text.

developing the technology used to implement the standard is the same regardless of how exactly it is developed. This also contrasts with the incremental ex ante approach, under which the royalty depends not only on the value of the technology to the user, but also on the state of ex ante competition. Thus, if competition were fierce in respect of a crucial aspect of a standard, and tame in respect of an aspect of that standard which added little value, under the incremental ex ante approach the total royalty for the latter could easily be more than for the former, in violation of the proportionality principle.

The royalty received by the single patentee under the contingent ex ante approach also balances the need for widespread adoption of the standard against a reasonable return to the patentee. In bargaining, a single patentee will take into account the fact that a lower royalty will result in more widespread adoption of the patent, and thus a larger overall surplus available to be split, while trading this off against the fact that the widest adoption would require a zero return to the patentee (unless perfect price discrimination is possible).[139] The contingent ex ante bargain therefore will result in a royalty which encourages the widest adoption of the standard consistent with a reasonable return to the patentee; and for this reason, the royalty stacking problem disappears. The Cournot complements problem arises when multiple patentees (or input providers more generally) do not take into account the externality in the form of reduced sales which their royalty imposes on other input providers.[140] The assumption that the user negotiates with the SSO for a single royalty, as it would with a single patentee holding all the relevant patents (whether that is one or many), solves this problem.

C. EX POST SHAPLEY PRICING

The next issue to consider is how to divide the royalty among the patentees. Although the contingent ex ante model is consistent with a variety of approaches, ideally the division of

139. In general, a monopolist will maximize profits by trading off higher prices for lower quantities sold, until marginal cost equates marginal revenue. *See, e.g.*, RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 332–33 (9th ed. 2014).

140. *See, e.g.*, Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, *in* 1 INNOVATION POLICY AND THE ECONOMY 119–50 (Adam B. Jaffe et al. eds., 2001) (providing a general version of Cournot's theory of complements cast in terms of blocking patents).

royalties should respect the proportionality principle—the idea that a patent more important to the standard receives a higher royalty than one that is less important—because this principle better serves the goal of dynamic efficiency. In this Section, we will argue that the contingent ex ante approach, combined with what we will call ex post Shapley pricing, respects the proportionality principle in a way that is both intuitively and theoretically appealing.

As discussed above, under Shapley pricing as applied to the standard setting context by Layne-Farrar et al., "the patent owners arrive at the SSO" in random order, and the Shapley value of a particular patent is its average marginal contribution over all possible arrival sequences.[141] We referred to this as ex ante Shapley pricing, as the Shapley value is determined before the patents are actually selected to be included in the standard: every patentee whose technology might have been selected is entitled to a royalty. In ex post Shapley pricing, by contrast, rather than considering the contribution of all patentees whose technology *might* have been selected to implement the standard, we apply Shapley pricing to all patentees whose technology actually *was* selected to implement the standard. In the simple example discussed earlier, the problem is captured by assuming that a standard consists of two complementary functionalities, *A* and *B*. The components are strict complements, which is to say that the standard is worthless unless both components are present.[142] In Case 1, assume that there is perfect competition ex ante for both components. That is, there are multiple patented technologies *A1*, *A2*, etc., which could provide functionality *A*, and multiple patented technologies *B1*, *B2*, etc., which could provide functionality *B*. Two of these, *A1* and *B1*, are selected by the SSO to be part of the standard. Each user is willing to pay $200 for the operational standard, and with equal bargaining power each pays $100. If *A1* arrives first, the standard is not operational and no user will be willing to pay anything. If *B1* then arrives, a functional standard can be implemented and the value to be split between the patentees is $100. *A1*'s marginal contribution is zero, and *B1*'s marginal contribution is $100. But if *B1* arrives first, the results will be exactly the opposite. Therefore, the two patentees will share

141. *See supra* notes 112–13 and accompanying text.
142. *See* Layne-Farrar et al., *supra* note 14, at 689.

the available royalties equally, which is to say $50.[143] This seems intuitively reasonable, given that the standard is not operational without both.

Now consider a standard in which the patents are not strictly complementary. Not all patents which are "essential" to a standard are necessarily strictly complementary, in the sense that a valuable standard could not be implemented at all without them. Most obviously, patents which are necessary to implement an optional part of a standard are nonetheless considered essential, at least under the IEEE-SA Bylaws.[144] More importantly, even patents that are required to implement a mandatory part of the standard are not necessarily strictly complementary.[145] For example, in a WLAN standard a particular technology might be required to implement a high-throughput protocol which is mandatory for an advanced standard. Even if the particular standard itself cannot be implemented without that technology, and even assuming that there are no alternatives to the patented high-throughput technology, an operable and commercially useful standard can be implemented without the higher throughput capability, though the standard with the high-throughput technology is more valuable than one without it. The question is how to allocate the value of the standard as a whole between the various technologies. For example, consider a stylized WLAN standard in which technology *A* is required for the basic transmission function, while technology *B* provides advanced security. A WLAN standard could be implemented using technology *A* alone, but *B* is use-

143. Compare with the incremental ex ante approach, in which each patentee would receive $0 in this scenario; and ex ante Shapley pricing, in which each patentee would receive $50/*N*, where *N* is the number of functionally equivalent patented technologies which might have been incorporated in the standard.

144. *See* IEEE-SA STANDARDS BOARD BYLAWS 6.1 (INST. OF ELEC. & ELECS. ENG'RS, INC. 2015), http://standards.ieee.org/develop/policies/bylaws/sb_bylaws.pdf.

145. Patents that are all essential to a mandatory part of a standard are complementary in the sense that a compliant implementation of the standard is impossible without using (or infringing) the patented technology. We will refer to this as "legal" complementarity, in contrast to the "technical" complementarity which arises when there are superadditive effects from using two technologies in tandem. Our discussion in the text refers solely to technical complementarity, on the view that the reasonable royalty should reflect the value of the standard to the user, and the value to the user lies in the technical functionality of the standard. *See* Taylor, *supra* note 16 (emphasizing that the royalty should reflect the technology).

less without *A*. Each user would be willing to pay $100 for a standard implemented with technology *A* alone, and $120 for the standard with the additional security provided by technology *B*. By the same methodology, the royalties would be $110 to *A1* and $10 to *B1*.[146] The intuition is that *A1* is entitled to more than $100 because it supplies all of the value derived from the transmission function alone ($100), and some of the value derived from the security function, which is worthless without the transmission function.

In principle ex post Shapley pricing can easily be extended to any combination of patents. For example, if two strictly complementary technologies, *A* and *B*, are required to implement the transmission function, and one technology *C*, is required for the security functionality, the royalties would be *A1* = $56.67; *B1* = $56.67; *C1* = $6.67. If two complementary technologies, *C* and *D*, are required to implement the security functionality, the royalties would be: *A1* = $55; *B1* = $55; *C1* = $5; *D1* $5. If one technology, *A*, is required to implement the transmission function, and three complementary technologies, *B*, *C*, and *D* are required for the security functionality, the royalties would be *A1* = $105; *B1* = $5; *C1* = $5; *D1* = $5. If three complementary technologies, *A*, *B*, and *C* are required to implement the transmission function, and one technology, *D* is required for the security functionality, the royalties would be *A1* = $38.33; *B1* = $38.33; *C1* = $38.33; *D1* = $5.

Ex post Shapley pricing therefore satisfies the proportionality principle in an intuitively reasonable way. No doubt there are other possible mechanisms for dividing the total value received by the patentee which would also satisfy the proportionality principle, though Shapley pricing also has a number of characteristics which make it particularly attractive.[147] These examples at least show that a principled method of dividing the royalties which satisfies the proportionality principle is theoretically possible.

Ex post Shapley pricing contrasts with several other possible methods for dividing the royalties that clearly do not satisfy proportionality. Some patent pools, for example, simply allocate royalties to each patentee according to the number of patents it

146. Arrival order (*A1*, *B1*) = $100 *A1*, $20 *B1*; (*B1*, *A1*) = $0 *B1*, $120 *A1*: average is *A1* = $110, *B1* = $10.

147. *See infra* Appendix A.

holds.[148] This method, which we refer to as numeric proportionality, has the practical advantage of simplicity (and may well be justified for that reason in some circumstances), but it clearly does not satisfy proportionality in the sense we are using that term.

Nor does incremental ex ante pricing satisfy the proportionality principle, because the royalty received under the latter is determined by whether there are alternatives ex ante, not by the importance of the technology. Thus, as we have seen, a key technology with several alternatives may get a zero return, while a secondary technology with few alternatives may receive a high return. To illustrate, in our WLAN example if only one technology is needed to implement the transmission functionality and one to implement the security functionality, under Shapley pricing the technology actually used for transmission (*A1*) would receive a royalty of $110, while the technology used for security (*B1*) would receive $10, regardless of how many technologies were competing ex ante. By contrast, under the incremental ex ante approach, the royalties will depend on the number of technologies available ex ante. If there are three equally good alternative technologies (*A1*, *A2*, and *A3*) available ex ante which could be used to implement the transmission functionality, but only one (*B1*) available to implement the security functionality, the royalty payable to *A1* will be $0, and to *B1* $120. This result clearly would not be consistent with the proportionality requirement[149]—and in general, neither would ex ante Shapley pricing, because the royalty for an important technology will be diluted if there were many equivalents ex ante.

Finally, we note that the most straightforward implementation of the contingent ex ante method will also apportion the royalties according to the value of the technology to each user,

148. *See, e.g.*, John M. Browning & Carla S. Mulhern, *Licensing in the Presence of Technology Standards*, LICENSING J., Aug. 2009, at 18, 26–27. Sidak asserts that applying Shapley pricing to SEPs would necessarily result in numeric proportionality because all SEPs are by definition essential. *See* Sidak, *supra* note 14, at 1043–44. But, this misses the point that a valuable standard could be created without every patent that is essential to the chosen standard. Users sometimes have little if any use for some SEPs, as was true for the video interlacing feature of H.264.

149. An analogous proposal was specifically rejected by Judge Robart in *Microsoft* as being an attempt by Motorola to extract the value of the standard. *See* Microsoft v. Motorola, No. C10-1823JLR, 2013 WL 2111217, at *44 (W.D. Wash. Apr. 25, 2013), *aff'd*, 795 F.3d 1024 (9th Cir. 2015).

not just its value to the standard. This is consistent with the case law.[150] We have generally left open the question of whether the SSO is assumed to bargain with each user individually or with users as a group. The easiest and correct approach, which is also consistent with the case law,[151] is to imagine that each individual user bargains with the SSO for the right to use the standard, contingent on the standard having been adopted and in the knowledge that other users will therefore also adopt the standard. A user who values the standard more will be willing to pay more for it. Further, a user who values particular aspects of the standard more or less will pay more or less for those aspects. For example, suppose there are two users, *X* and *Y*. Both value the basic transmission capability of a standardized WLAN at $100, but *X* would be willing to pay $140 for a standard that also includes the security feature, while the security feature is worthless to *Y*, who would only pay $100 for the right to use the standard, whether or not it has the security functionality. Even though both are licensing the entire standard, under the contingent ex ante approach, *X* would have to pay $140 in royalties for the standard and *Y* would have to pay only $100 for the same standard. Further, if we add ex post Shapley pricing, the return to each patentee will reflect the importance of the patent both to the particular user and to the technology as a whole. If *B* brought an action against *X*, a reasonable royalty using the contingent ex ante method with ex post Shapley pricing would be $20, but if *B* brought an action against *Y*, the reasonable royalty would be zero.[152]

This approach also automatically satisfies the apportionment principle that the royalty should reflect the value of the technology to the standard, since the value to the standard is simply the aggregate of the value to the individual users.[153] In contrast, the incremental ex ante approach is generally not consistent with the apportionment principle. It would be possible to apply that approach on a user by user basis, but the

150. *See In re* Innovatio IP Ventures, No. 11 C 9308, 2013 WL 5593609, at *6 (N.D. Ill. Oct. 3, 2013); *Microsoft*, 2013 WL 2111217, at *20, *42.

151. *See, e.g.*, *Microsoft*, 2013 WL 2111217, at *20 (holding that the royalty must reflect the value of the technology to the particular user); *id.* at *47–49 (noting that the technology at issue was of minimal importance to Microsoft's products).

152. The FRAND royalty payable by *X* to *A* would be $120 and by *Y* to *A* would be $100.

153. *See Innovatio*, 2013 WL 5593609, at *6.

value of each patent embodied in the standard is determined by the state of ex ante competition, not on the value of the standard to a particular user. Suppose, for example, that there was perfect competition ex ante in the market for component *A*, and none for component *B*. If *B* brought an action against *X*, a reasonable royalty using the incremental ex ante approach would be $140. If *B* brought an action against *Y* the reasonable royalty would be zero, because even though there is no competition for that component, its incremental ex ante value is nonetheless zero so far as *Y* is concerned.[154] Conversely, suppose there was perfect competition ex ante in the market for component *B* and none for component *A*. If *B* brought an action against either *X* or *Y*, a reasonable royalty using the incremental ex ante approach would be $0.[155]

D. IMPLICATIONS

In the Introduction, we conceded that our proposed theoretical framework—under which a FRAND royalty reflects an SEP's incremental contribution to the value of the standard—probably cannot be directly implemented in practice (though the same is true of other idealized approaches, including the incremental ex ante approach). Although one might *imagine*, as we stated above, a three-step process in which an SSO negotiates an aggregate royalty with users in advance of the users having incurred any sunk costs,[156] in reality SSOs do not do this (nor do we suggest that they should). Any testimony about how such negotiations, had they actually occurred, would have transpired necessarily would involve a great deal of speculation. It is likewise difficult for us to imagine much good resulting from having experts "educate" juries in the intricacies of concepts like Shapley pricing. Given the costs and uncertainties of patent litigation as things stand, one might ask, what good is a theoretical model that either cannot be used at all, or only at enormous expense in terms of money and predictability?

The answer to this question is twofold. First, having an appropriate conceptual benchmark is useful in determining which of the seven principles set out in the Introduction should

154. The FRAND royalty payable by *X* or *Y* to *A* would be $0.

155. The FRAND royalty payable by *X* to *A* would be $140 and by *Y* to *A* would be $100.

156. Or, as described *infra* Appendix A, more accurately as a cooperative game with transferable utility.

be retained and which, if any, should be modified or discarded. Relatedly, the benchmark also helps to determine how best to interpret the principles that remain. Second, the benchmark can be useful in determining what sorts of practical evidence and methodological approaches should be admissible—namely, those that are likely to be consistent with the conceptual benchmark, as opposed to those that are not. We elaborate below.

1. Principles To Retain, Modify, or Discard

First, as discussed above (and in greater detail in Appendix A), Shapley pricing is the natural interpretation of the incremental contribution of one technology when the value of the standard is greater than the sum of its parts. Shapley pricing in our model implements the incremental value principle, and is therefore consistent with Judge Robart's statement that a "central" principle of (F)RAND royalties is that "the parties in a hypothetical negotiation would set RAND royalty rates by looking at the importance of the SEPs to the standard and the importance of the standard and the SEPs to the products at issue."[157] Our model therefore provides a central role for Principle (4), the proportionality principle.

Shapley pricing also provides a natural interpretation of Principle (3), the incremental ex ante principle, as meaning that the royalty any patentee can receive is capped by the ex ante incremental value of the patented technology as compared with the best unpatented alternative.[158] This contrasts with the implementation of the incremental ex ante principle in Swanson & Baumol's auction model. Our analysis in Parts II and III above shows that if the incremental ex ante principle is understood as meaning the incremental value of the selected technology over the best alternative patented technology, it is inconsis-

157. Microsoft v. Motorola, No. C10-1823JLR, 2013 WL 2111217, at *3 (W.D. Wash. Apr. 25, 2013), *aff'd*, 795 F.3d 1024 (9th Cir. 2015). Judge Holderman has similarly stated that the royalty to a particular patentee must reflect the value that patent contributes to the functionality. *See Innovatio*, 2013 WL 5593609, at *10 ("Imagine, for example, that the court has determined that a given patent portfolio provides 25% of the functionality of a standard, and that the court is considering a proposed RAND rate based on that determination. Logically, the other standard-essential patents outside of the portfolio should comprise 75% of the value of the standard, or three times the value of the asserted portfolio.").

158. See *infra* Appendix B for a more detailed description of how this emerges from our model.

tent with both the incentive-to-invent and proportionality principles, because the patentee's reward depends more upon the state of ex ante competition than upon the value that implementers derive from the use of the invention. The result may be a reward that either overcompensates or undercompensates the inventor in relation to the invention's contribution to the standard—and to the extent the result is likely to be *under*compensation, the incremental ex ante approach also undermines Principle (6), the incentive to participate in SSO activities. Given the centrality of the incentive-to-invent and proportionality principles to a system of patent incentives,[159] this analysis leads us to conclude that courts should discard the incremental ex ante approach, at least in its "pure" Swanson & Baumol form.

Our guiding principle is that the patentee is entitled to its incremental contribution *to the value of the standard*, which excludes any part of the implementers' sunk costs. Thus, under our analysis, statements to the effect that royalties should reflect the value of the technology, not the value of the standard (Principle (5)), should be interpreted to mean only that a patent making a relatively small contribution to the value of a standard should not command a royalty that reflects the value of the other, more important patents, nor should it reflect the implementers' sunk costs. To permit the royalty to reflect the value of the standard in this sense would violate the proportionality principle, among other things. At the same time, however, dynamic efficiency considerations counsel in favor of permitting the royalty to reflect a share of the value of standardization, understood as the additional value arising from widespread adoption of the technology on standardization, which is proportionate to the technology's contribution to that value. There is no reason to treat value arising from widespread use due to standardization differently from value arising from widespread use due to a product that is successful for other reasons.

Significantly, both the IEEE-SA Bylaws (which defines a "Reasonable Rate" as "appropriate compensation to the patent holder for the practice of an Essential Patent Claim excluding the value, if any, resulting from the inclusion of that Essential

159. Though, as noted above, cost considerations sometimes might trump application of proportionality in favor of something simpler, such as numeric proportionality. *See supra* text accompanying note 147. Nevertheless, we think that proportionality should be the default principle.

Patent Claim's technology in the IEEE Standard"[160]) and the *Microsoft* decision can be read in this fashion. As for the latter, Judge Robart noted that, although there was "clear value to implementers . . . to offer products compliant with the H.264 Standard, this value reflects the value of standard compliance and interoperability, not the value of any individual patents."[161] Consequently, testimony that related only to the general importance of the H.264 standard to Microsoft's products "reflects an improper attempt by Motorola to capture the value of the H.264 Standard itself as opposed to a royalty on the actual economic value of Motorola's patented technology."[162] Similarly, the no holdup principle (Principle (1)), should be understood as standing for the proposition that the patentee cannot capture any part of the user's sunk costs or the value of other technologies, but it is unobjectionable for the patentee to appropriate some part of the increased value derived from network effects on standardization.

Once we decide that the patentee is entitled to its incremental contribution to the overall value of the standard, the incentive to invent and the incentive to participate (Principles (6) and (7)) are automatically satisfied. Because the value distributed to the patentee is proportionate to the value to the user—unlike the auction model—the incentive to invent is proportionate to the social value, as in the patent system generally. To depart from Shapley pricing by increasing the reward to one patentee, with a corresponding reduction to another patentee, would provide an excessive incentive to invent to the first and an inadequate incentive to invent to the second. If this reward does not cover the costs of invention, this is simply because, with the benefit of hindsight, we can see that the invention was

160. IEEE-SA STANDARDS BOARD BYLAWS 6.1 (INST. OF ELEC. & ELECS. ENG'RS, INC. 2015), http://standards.ieee.org/develop/policies/bylaws/sb_bylaws.pdf. In particular, we would argue that "the value of the patented feature," the "value of [the] patented technology," and "appropriate compensation to the patent holder" should be understood as including a portion of the increased value due to network effects, but not any value *beyond* the patent's marginal contribution to the standard. This "value beyond" would include sunk costs, differential opportunity costs, and the marginal contribution of other patents. *See supra* note 42.

161. *Microsoft*, 2013 WL 2111217, at *42. Judge Robart further stated that "negotiating parties would consider only the economic value of the patented technology—based on the technology's contribution to the standard and to the implementer's product itself—apart from the value associated with the standard." *Id.*

162. *Id.* at *44.

not worth the investment. If this reward does not provide an adequate incentive to participate, in the sense that the patentee can get a higher value by remaining outside the standard, this simply means that the patented technology is more valuable outside the standard than as part of it.[163] Further, it is the patentee who actually contributes to the standard who is entitled to a reward, not a patentee who might have been included in the standard. This is necessary to provide the correct incentive to invent, given that it is only a patentee whose patent is actually infringed can sue for infringement and collect a royalty.

As for Principle (2), in our framework the anti-royalty stacking principle is really just an outgrowth of proportionality: no individual patent should command a disproportionate share of its marginal contribution to the standard. The patentees as a group are entitled to only a part of the value of the standard to the user; because they cannot capture the user's sunk costs, they cannot obtain more than the value to the user. Consequently, the royalties cannot be excessive, in the sense that the user will always pay less in royalties than the standard is actually worth to it. Translated into practical terms, if the patent in suit contributes relatively little to the standard, but the royalty sought by the patent owner multiplied by the number of other SEPs incorporated into the defendant's product would exceed the revenue derived from that product, it is reasonable to infer that the royalty is disproportionate.[164]

163. Anne Layne-Farrar et al. consider an ex ante incremental value rule under which the patentee would be entitled to the incremental increase in expected value contributed by its patent, where the expected value turns on the increased probability of success if the patentee participates in the standard. *See* Layne-Farrar et al., *supra* note 11, at 27, 29. They show that this rule does not ensure adequate participation because it does not fully distribute the profits of a successful standard, so under plausible conditions the patentee will choose to stay out of the standard and negotiate participation ex post. *Id.* Our model avoids the participation problem they address because the profits of the successful standard are fully distributed to the participating patentees, so there is no advantage to be gained by staying out initially.

164. *See In re* Innovatio IP Ventures, LLC Patent Litig., No. 11 C 9308, 2013 WL 5593609, at *10 (N.D. Ill. Oct. 3, 2013) ("[T]he court conclude[d] that royalty stacking may be a concern when setting a RAND rate to ensure that the asserted patents are not overvalued compared to the technological contribution they make to the standard."); *Microsoft*, 2013 WL 2111217, at *73 (noting concerns due to the patent contributing little to the applicable standard).

2. Practical Implications

One direct practical implication of our approach is that it is proper to award a running royalty either as damages for past infringement or as an ongoing royalty in lieu of an injunction. This may seem so unremarkable as to not be worth mentioning. Reasonable royalties are routinely awarded on the basis of a running royalty; no one has ever suggested that this is improper,[165] and we agree that it is not. But if we take seriously the principle that the SEP owner should not capture any of the value arising from network effects, the standard practice of awarding running royalties would be entirely wrong. The increased social value of the standard due to network effects is partly reflected in increased value of the technology to individual users, but the most direct effect is on sales; more people will adopt the technology after standardization. That being so, any running royalty in which the amount owing to the patentee increases with total sales will reflect in large part the increased value of the technology due to standardization. If the SEP owner were not entitled to capture any of the value arising on standardization, understood as including network effects, then the only proper reasonable royalty would be a lump sum based not on actual sales, but on the sales that would have been anticipated had the technology never become part of the standard. The fact that no one has ever proposed such an absurd rule suggests to us that, whatever it might mean to say that the SEP owner is not entitled to capture the value arising on standardization, it cannot mean that the patentee is not entitled to any part of the value arising from network effects.

A second direct implication of our approach relates to the timing of the hypothetical negotiation. Courts often refers to the hypothetical negotiation occurring just prior to the first infringement,[166] but the literature sometimes refers to a date prior to the incurring of sunk costs[167] or prior to standardiza-

165. *See, e.g.*, Lucent Techs., Inc. v. Gateway, Inc., 580 F.3d 1301, 1326 (Fed. Cir. 2009) (discussing a running royalty license, without any suggestion that it is improper).

166. *See, e.g.*, *id.* at 1324 ("The hypothetical negotiation or the 'willing licensor-willing licensee' approach . . . attempts to ascertain the royalty upon which the parties would have agreed had they successfully negotiated an agreement just before infringement began.").

167. *See* William F. Lee & A. Douglas Melamed, *Breaking the Vicious Cycle of Patent Damages*, 101 CORNELL L. REV. 385, 426 (2016) ("The hypothetical negotiation date should be set at just prior to the time that the infringer became committed to using the infringing technology, which in most cases will

tion.[168] While these dates sometimes coincide, this is by no means necessary either in theory or in practice. Consistent with a recent proposal by Lee and Melamed,[169] under our approach the correct date is a date prior to the defendant's having incurred sunk costs. Since this date may occur prior to infringement, using the date of first infringement would facilitate the patentee's ability to extract sunk costs. At the same time, the proposal that the hypothetical negotiation should take place prior to standardization is premised on the view that the patentee should not be able to capture any value arising from network effects, which is also inconsistent with our approach. Nevertheless, choosing the correct date is not quite as crucial under our approach because whichever date is chosen, the negotiation is assumed to take place will full ex post knowledge (so a date that is too *early*, at least, makes no difference). Further, we emphasize that the notion of an ex ante hypothetical negotiation is only a mechanism to ensure that sunk costs holdup is not permitted; so long as the particular evidence used to assess the reasonable royalty does not itself reflect sunk costs, the exact date of the negotiation is irrelevant.

Beyond this, our proposed approach can help courts to determine which evidence and methodologies should be admitted in evidence (possibly with modifications), and which should not. For example, courts often consider comparable licenses as a guide to determining the royalty a willing licensor and licensee would have agreed to,[170] and our approach can be useful in analyzing which licenses should be considered comparable. In general, licenses that were negotiated against a backdrop of unpatented alternatives are more likely to be comparable under our approach than would licenses negotiated ex post against a threat of injunctive relief (which would enable the licensor to extract a portion of sunk costs).[171] In addition to these simple

be the lock-in date.").

168. *See* Contreras & Gilbert, *supra* note 55, at 1491–92 (considering the positive impact of having the hypothetical negotiation prior to standardization).

169. *See* Lee & Melamed, *supra* note 167.

170. *See, e.g.*, *Lucent Techs., Inc.*, 580 F.3d at 1305 (using rates paid for comparable licenses as a guide in determining if the jury's royalty payment assessment in determining damages was reasonable).

171. Though whether licensors routinely do extract sunk costs is, ultimately, an empirical issue. *See* Wright, *supra* note 65, at 807 ("Although the rate negotiated with the injunction threat is likely greater than the rate negotiated without the threat of injunction, it does not follow that the former is above

observations, however, we can also use our approach to evaluate the methodologies the courts have approved in the cases thus far.

For example, in *Microsoft* two families of patents were at issue, one relating to the Wi-Fi 802.11 standard, the other to the H.264 video coding standard.[172] In addressing the Wi-Fi standard, the court applied the proportionality principle to exclude consideration of a majority of the asserted Wi-Fi patents on the basis that even if they were essential to the standard, it was not alleged that they were practiced by the Microsoft products at issue.[173] Judge Robart also gave extensive consideration to the importance of the asserted patents to the standard and to Microsoft's products in particular, concluding that the patents related to the H.264 standard generally provided only a modest contribution to the standard, and those related to the 802.11 standard generally provided very little contribution to the standard.[174] As a consequence, the court held that Motorola was not entitled to any increase in the FRAND rate that had been derived from the best comparable license for the H.264 patents,[175] and for the 802.11 patents the court held the standard rate derived from the comparable license represented a ceiling which was likely higher than the appropriate FRAND rate.[176] These uses of proportionality are consistent with our recommended approach.

On the other hand, with regard to the relevance of ex ante alternatives our analysis is somewhat different from that of Judge Robart, who considered whether there were ex ante alternatives to the patents at issue without distinguishing between patented and unpatented alternatives.[177] Under our ap-

F/RAND.").

172. Microsoft Corp. v. Motorola, Inc., No. C10-1823JLR, 2013 WL 2111217, at *1 (W.D. Wash. Apr. 25, 2013), *aff'd*, 795 F.3d 1024 (9th Cir. 2015).

173. *See id.* at *55 (discussing the 802.11 patents).

174. *Id.* at *84, *98. Judge Robart held that the remaining Wi-Fi patents generally contributed very little to the standard. *Id.* at *57–58, *60, *63. The patents related to the H.264 standard were somewhat more important to that standard. *See id.* at *28–29, *32–33, *39 (analyzing the importance of the patents related to H.264 in relation to that standard). However, that importance was substantially diminished because almost all of them (fourteen of sixteen) related only to interlaced video, which was of minimal importance to Microsoft's products. *Id.* at *39, *42, *47–49.

175. *Id.* at *86.

176. *Id.* at *92.

177. *See id.* at *53 ("If viable alternatives existed, the patents are less im-

proach, only the latter would be relevant.[178] Nevertheless, on the facts the court held that that availability of alternatives had not been established or that the selected technology was superior,[179] so the availability of ex ante alternatives (patented or not) did not have any impact on the outcome. Similarly, Judge Robart cited as the theoretical ideal the incremental ex ante approach that our proposal rejects,[180] but when he actually came to apply the principle that a patentee is only entitled to the value of its technology, he interpreted it in a manner consistent with our approach, as meaning that the patentee is not entitled to a disproportionate share of the royalties.[181]

Ultimately, the court in *Microsoft* based the FRAND rate ranges on comparable rates charged by patent pools,[182] despite noting a number of shortcomings with pools generally as comparables. We agree with the court's assessment of at least some of these shortcomings,[183] but there is one criticism that we view as misplaced: namely, its concern that:

> [P]atent pools do not use an incremental value approach, an approach that is required in the court's hypothetical negotiation paradigm. In other words, patent pools do not try to determine the incremental value of every patent in the pool compared to alternatives that were available prior to defining the standard.[184]

As noted above, however, the court did not distinguish between patented and unpatented alternatives, and under our approach the failure to consider the incremental value over patented al-

portant to the standard and will be valued accordingly."); *see also id.* at *38 (considering an alternative which was identified as patented).

178. *See infra* Appendix B.

179. *See Microsoft*, 2013 WL 2111217, at *28, *30, *36, *38, *41–42 (H.264 patents); *id.* at *54 (802.11 patents).

180. *See id.* at *14.

181. *See id.* at *42.

182. *See id.* at *82 (discussing the MPEG LA H.264 pool for the video coding patents); *id.* At *89 (discussing the Via Licensing 802.11 patent pool for Motorola's 802.11 SEP portfolio). The court rejected the various licenses suggested by Motorola as comparables for reasons unrelated to our approach, such as the fact that they were negotiated under threat of a potential infringement action or were part of a larger license of both standard-essential and other patents. *Id.* at *67, *69, *71–72.

183. For example, Judge Robart stated that "the patent-counting royalty allocation structure of pools does not consider the importance of a particular SEP to the standard or to the implementer's products." *Id.* at *80. His concern that patent counting (numeric proportionality) might reduce the incentive to participate for patentees with valuable patents, *id.*, is fundamentally the same as ours.

184. *Id.* at *80 (citation omitted).

ternatives is not a defect at all,[185] while the failure to consider unpatented alternatives is important only if there is evidence that there were unpatented alternatives that might have made a similar contribution (which there was not in this case). More generally, the use of patent pools can be consistent with our theory. We have argued that the appropriate benchmark for a FRAND royalty is that the total royalty paid by the user should be the same as the royalty that a user would pay to a single patentee holding all the relevant patents. An ideal pool would do exactly this, and the balance which a pool seeks between widespread adoption and income for the patentees[186] is the same trade-off which would be faced by a single patentee seeking to maximize its revenue without pricing itself out of the market. Most of the problems with using pools as comparators relate to the distribution of the royalties among the various licensors with patents of differing value.[187] This is certainly an important problem from the patentee's perspective, but from the user perspective, which is to say in terms of the total royalty payable to license a standard, a successful patent pool is the best possible comparator.

Similarly, the court's analysis in *Innovatio*[188] is broadly consistent with our approach. In *Innovatio*, Judge Holderman employed what was referred to in the case as a "Top Down" approach by, first, determining the applicable royalty base (here, a Wi-Fi chip, which the court determined was the smallest salable patent practicing unit);[189] second, calculating the average

185. *See infra* Appendix B.

186. *See Microsoft*, 2013 WL 2111217, at *82 ("[The] two cornerstones of the RAND obligation [are]: (1) . . . to create valuable standards, while at the same time, (2) ensuring widespread adoption.").

187. *Id.* at *80. The other main problem is that in some pools, important licensors are also users, which means they are willing to accept less than their proportionate share of the standard as licensors because of the compensating benefit of a low rate to them in their role as licensees. *Id.* at *81. Judge Robart acknowledged this problem and explicitly accounted for it in his FRAND rate calculation. *See id.* at *81, *85.

188. *In re* Innovatio IP Ventures, LLC Patent Litig., No. 11 C 9308, 2013 WL 5593609 (N.D. Ill. Oct. 3, 2013).

189. *See id.* at *12–18. In a series of decisions, the Federal Circuit has held that the "entire market value" of an end product may serve as a royalty base only when "the patented feature drives the demand for an entire multi-component product." LaserDynamics, Inc. v. Quanta Comput., Inc., 694 F.3d 51, 67 (Fed. Cir. 2012). As a general rule, the correct base is the "smallest salable patent-practicing unit." *Id.* (quoting Cornell Univ. v. Hewlett-Packard Co., 609 F. Supp. 2d 279, 283, 287–88 (N.D.N.Y. 2009)); *see also* Virnetx, Inc. v. Cisco Sys., Inc., 767 F.3d 1308, 1327–28 (Fed. Cir. 2014) (holding that, even

sales price of a chip over what the court viewed as the relevant time period ($14.85);[190] third, multiplying that price by the average profit margin over that period (12.1 percent), thus lowering the base to $1.80;[191] fourth, multiplying the base by eighty-four percent, the value believed "attributable to the top 10% of 802.11 standard-essential patents, to obtain $1.51";[192] and fifth, multiplying $1.51 by 19/300, based on an estimate that there are approximately 3000 patents essential to the standard at issue (resulting in 300 falling within the "top 10%") and that Innovatio's 19 SEPs (which the court viewed as moderate to moderate-high in importance) were among these 300 top patents.[193] Consistent with our proposal, this approach eliminated the risk of royalty stacking and accorded proportionately more value to the patents deemed important to the standard.[194]

That said, we would suggest some modifications that would conform the top-down approach more closely to our own. First, and perhaps most importantly, Judge Holderman reconstructed the average chip price from 1997 (the date of the hypothetical negotiation) to 2013 (by which date all but three of the patents had expired), to calculate a royalty base of $14.85.[195] In doing so, Judge Holderman rejected the expert's proposal to use a *weighted* average of $3.99—which reflected much lower chip prices in the later years as the number of units sold increased (from 5.4 million in 2000 to over 2 billion in 2015)—reasoning that the increase in chip sales was "due to the increased demand for Wi-Fi products resulting from the interoperability of the products due to standardization," and that the court must

after identification of the smallest salable patent-practicing unit, further apportionment may be necessary).

190. *Innovatio*, 2013 WL 5593609, at *41.

191. *Id.*

192. *Id.* at *43 ("[T]he top 10% of all electronics patents account for 84% of the value in all electronics patents." (citing Mark Schankerman, *How Valuable Is Patent Protection? Estimates by Technology Field*, 29 RAND J. ECON. 77, 94 tbl.5 & n.12 (1998))). Whether this estimate still holds poses an interesting question. See Sidak, *supra* note 14, at 1019–20, for discussion in the context of IEEE's 802.11 wireless standard.

193. *Innovatio*, 2013 WL 5593609, at *38–39, *43. The court noted, however, that "many of those 3000 patents are likely less valuable to the standard than Innovatio's patents because their essentiality has not been judicially confirmed." *Id.* at *43.

194. *See id.* (according more value to the patents deemed important).

195. *Id.* at *41. Because the relevant data went back only to 2000, Judge Holderman assumed that the average price per chip during 1997–99 was the same as the average price for 2000. *Id.*

"not consider the effect of standardization when evaluating the ex ante negotiation in 1997."[196] In our view, however, it would have been appropriate to use the lower number. Under the contingent ex ante framework, the relevant question is what royalty the parties would have agreed to ex ante, with the benefit of all relevant ex post information (here, the fact that the standard was successful and that chip prices declined more rapidly in recent years). Using this ex post information in *Innovatio* actually might have resulted in a lower royalty rate.[197] Second, for somewhat more technical reasons, we question whether the court was correct to reduce the base by the average profit margin on sales of Wi-Fi chips during the period in question.[198]

196. *Id.* at *39–41.

197. We say "might," because, as discussed *infra* note 198, we are not sure that the court's next step, of reducing the base by the average profit margin per chip, was correct. In theory it is also debatable whether the base should normally be the smallest salable patent-practicing unit, or whether it could be the revenue from sales of the entire infringing device (as may be common outside the litigation setting). *See* Ericsson, Inc. v. D-Link Sys., Inc., 773 F.3d 1201, 1228 (Fed. Cir. 2014) ("[Jury] instructions [must] fully explain the need to apportion the ultimate royalty award to the incremental value of the patented feature from the overall product."). Courts in the U.S. prefer use of the smallest salable patent-practicing unit largely out of concern that juries will otherwise award inappropriately large royalties, even though (as a matter of theory) a large base multiplied by a smaller rate could be identical to a small base multiplied by a larger rate. *Id.* at 1226–27. In the context of a top-down approach, however, use of the smallest salable patent-practicing does have the advantage of eliminating from consideration all of the SEPs that read on other components of a multicomponent end product.

Somewhat in contrast to the court in *Innovatio*, the district court in *Microsoft* "did to an extent take into account" ex post information, specifically "the present-day value to Microsoft of Motorola's patents" in concluding that "a third-party valuation of Motorola's 802.11 SEPs was only somewhat probative because, at the time of the valuation, 'Motorola's 802.11 SEP portfolio' was much larger than the portfolio 'as it exists today.'" Microsoft Corp. v. Motorola, Inc., 795 F.3d 1024, 1041 (9th Cir. 2015) (quoting Microsoft Corp. v. Motorola, Inc., No. C10-1823JLR, 2013 WL 2111217, at *97 (W.D. Wash. Apr. 25, 2013)). The appellate court found no error in this, stating that "it would have been impracticable for the court to consider only such evidence as could pinpoint the value of Motorola's patents to Microsoft at a precise point in time" and noting, among other things, "the need for flexibility in determining a royalty rate for a RAND-encumbered patent." *Id.* at 1042.

198. The rationale for using the average profit was to "isolate[] the portion of the income from the sale of the chip available to the chipmaker to pay royalties on intellectual property," but the logic is not obvious. *Innovatio*, 2013 WL 5593609, at *38. Realistically, one might expect that some portion of the $13.05 cost of producing chips ($14.85 less the $1.80 profit margin calculated by Judge Holderman) was itself due to payment of royalties for some of the other 3000 or so patents (though presumably some of them may not have been licensed ahead of time). Moreover, even if we ignore that point, the court's

Finally, there's *Ericsson*, one of the few appellate decisions to date to address the subject of FRAND royalties. Correctly in our view, the *Ericsson* court stressed the need for the royalty to be proportionate in the sense that an SEP making only a small contribution to the standard should receive a commensurately small royalty, not one that reflects the value of the standard as a whole.[199] Nevertheless, as noted in the Introduction, the *Ericsson* court also emphasized that the "royalty must be premised on the value of the patented feature, not any value added by the standard's adoption of the patented technology."[200] We have shown that the distinction between the value of the technology and the value added by standardization is by no means clear,[201] and that the latter term has been used to refer to sunk costs holdup, network value appropriation, and the problem of apportionment. As we have noted, these concepts are routinely conflated, and *Ericsson* is no exception, so it is not clear how that instruction is to be understood—though the court did seem to view its concern about capturing the value added by stand-

analysis seems to contemplate all of the chip maker's profits potentially being eaten up by IP rights (if all 3000 SEP owners demanded royalties), which seems unlikely. In theory, a better method would have been to determine what portion of the cost of producing chips is typically attributable to IP and what portion is attributable to other factors, and then to divide up the "IP portion" in accordance with the importance of the patents in suit. One recent study, for example, claims that about twenty-five percent of the cost of producing an entire smartphone goes to patent royalties. Ann Armstrong et al., The Smartphone Royalty Stack: Surveying Royalty Demands for the Components Within Modern Smartphones 2 (May 29, 2014) (unpublished manuscript), http://ssrn.com/abstract=2443848. We make no claims concerning the accuracy of this number. Such information may not be available, however, in which case perhaps there is no obvious way to avoid some arbitrary limitation.

199. *See Ericsson*, 773 F.3d at 1232–33 ("Just as we apportion damages for a patent that covers a small part of a device, we must also apportion damages for SEPs that cover only a small part of a standard. In other words, a royalty award for a SEP must be apportioned to the value of the patented invention (or at least to the approximate value thereof), not the value of the standard as a whole.").

200. *Id.* at 1232; *see also* Commonwealth Sci. & Indus. Research Org. v. CISCO Sys., Inc., 809 F.3d 1295, 1306 (Fed. Cir. 2015) (vacating a damages award, on the ground that "the district court erred in failing to account for value accruing to the '069 patent from the standard's adoption"); *Ericsson*, 773 F.3d, at 1233 (concluding that "Supreme Court precedent also requires apportionment of the value of the patented technology from the value of its standardization," and that the jury "must be told to consider the difference between the added value of the technological invention and the added value of that invention's standardization").

201. *See supra* text accompanying note 125.

ardization as distinct from the problem of apportionment,[202] and it addressed sunk costs holdup separately.[203] To the extent the *Ericsson* court *did* mean that the patentee is not entitled to appropriate any of the value of the standard, this holding is inconsistent with our theory. We therefore urge the Federal Circuit to distance itself from this interpretation in the future. Moreover, given the court's suggestion that "[t]rial courts should . . . consider the patentee's actual RAND commitment in crafting the jury instruction,"[204] we submit that courts can and should interpret the IEEE-SA Bylaw "excluding the value, if any, resulting from the inclusion of [an SEP] in the IEEE Standard"[205] in a manner that is consistent with our approach.

CONCLUSION

Courts and commentators have proposed various principles for calculating FRAND royalties, among them that the royalty should not reflect "the value of the standard." As we have shown, however, this principle could be understood to mean

202. *See Ericsson*, 774 F.3d at 1235 ("[D]istrict courts must make clear to the jury that any royalty award must be based on the incremental value of the invention, not the value of the standard as a whole or any increased value the patented feature gains from its inclusion in the standard."); *see also id.* at 1231 (stating that some of the *Georgia-Pacific* factors "need to be adjusted for RAND-encumbered patents," because the use of such patents is inflated due to their essentiality).

203. *Id.* at 1233–34.

204. *Id.* at 1231.

205. IEEE-SA STANDARDS BOARD BYLAWS 6.1 (INST. OF ELEC. & ELECS. ENG'RS, INC. 2015), http://standards.ieee.org/develop/policies/bylaws/sb_bylaws.pdf. In another document, however, the IEEE-SA states that:

> As a hypothetical example, during the development of a standard, a Working Group considers alternatives and makes a decision based on many factors. Suppose two and only two alternative technologies are available, both patented and both offering the same performance, implementation cost, and all other qualities. Therefore, the value of the two options is exactly the same, although only one will be selected. Any additional value imputed to the selected option because of its inclusion in the standard is excluded.

UNDERSTANDING PATENT ISSUES DURING IEEE STANDARDS DEVELOPMENT 13–14 (INST. OF ELEC. & ELECS. ENG'RS STANDARDS ASS'N 2016), https://standards.ieee.org/faqs/patents.pdf. The U.S. Department of Justice nevertheless interprets IEEE-SA's definition of "Reasonable Rate" as excluding "value arising from the cost or inability of implementers to switch from technologies included in a standard," which is what we mean by sunk costs holdup. Letter from Renata B. Hesse, Acting Assistant Att'y Gen., U.S. Dep't of Justice, Antitrust Div., to Michael A. Lindsay, Esquire, Dorsey & Whitney LLP (Feb. 2, 2015), http://www.justice.gov/sites/default/files/atr/legacy/2015/02/04/311470.docx.

any or all of three distinct concepts: that the royalty should not reflect the implementer's sunk costs; that the patentee should not extract any of the value resulting from network effects; or that the royalty should be proportionate to the patent's contribution to the standard. Failure to distinguish among them, or to classify all three as manifestations of holdup, results in questionable policy prescriptions, because only the sunk costs and proportionality problems are associated with static or dynamic inefficiency.

This Article has proposed the combination of a contingent ex ante framework for calculating reasonable royalties with ex post Shapley pricing, resulting in the foundational principle that a FRAND royalty should reflect the incremental contribution of the patent to the value of the standard to the user. As we have shown, our proposal would prevent patentees from extracting sunk costs or a disproportionate share of standard value, but (contrary to some other proposed approaches) it would enable them to draw some of the increased value resulting from network effects. Moreover, our framework interprets the various principles articulated to date in a manner that is largely consistent with the decided cases and that will enable courts to apply those principles coherently and consistently with sound innovation policy. Finally, while abstract, the proposal can be used as a benchmark for determining which types of practical evidence and methodologies courts should admit as proxies for the ideal approach.

Appendices to *The Value of the Standard*

Our discussion in the main body of the article describes the determination of a reasonable royalty as involving a hypothetical three-stage process. That description isolates some of the key features of our approach. These Appendices provide a more detailed technical explanation of our approach, though we do not provide a fully formal model. Appendix A provides a basic theoretical justification for the use of the Shapley value. Appendix B addresses two technical questions, namely whether the hypothetical negotiation is carried out by individual users or by users as a group, and how to deal with ex ante competition to be included in the standard.

I. APPENDIX A

In the main text we propose that FRAND royalties be determined by the incremental contribution of the patent to the value of the standard to the user, where the incremental value is determined by ex post Shapley pricing. This Appendix justifies the use of Shapley pricing.[206] We argue that the setting of a FRAND royalty should be conceptualized as the outcome of a cooperative game with transferable utility. Adopting the Shapley value as the solution concept flows naturally from this basic modeling choice.

In game theory, cooperative games are those in which players are able to enter into binding commitments.[207] In non-cooperative games, in contrast, players act independently; they may anticipate how others will respond and adjust their behavior accordingly, but they do not have the ability to bind each other to any particular course of action.[208] For example, the famous Prisoners' Dilemma is a non-cooperative game in which the dilemma arises because neither player can bind the other to the choice that is in their mutual best interest.[209] If the same problem were modeled as a cooperative game, the players would be able to enter into a binding agreement not to defect.

A basic question is whether the FRAND process should be modeled as a cooperative or non-cooperative game. In our view, the choice is clear. The patent system itself can only be modeled as a cooperative game. The central justification for the patent system is that without the ability to make binding commitments between agents—namely innovators and users—innovation incentives reduce to a prisoners' dilemma: if the inventor "cooperates" by inventing, it is in the user's interest to "defect" by buying a cheaper copy from a free-rider who did not incur the sunk costs of invention. Anticipating this, the inventor will "defect" by not investing in invention. If the user cooperates by paying up front, it is in the inventor's interest to defect by not investing sunk costs in invention. The patent system solves this dilemma by (in effect) allowing the user to make a binding commitment to pay if it chooses to use the invention. The property right granted by the state to the inventor repre-

206. The use of ex post information is addressed in the main text and in our companion article, Siebrasse & Cotter, *supra* note 15.

207. *See* OSBORNE & RUBENSTEIN, *supra* note 113, at 2.

208. *See id.*

209. *Id.* at 16.

sents the binding commitment by users as a group to "cooperate" by paying for the invention if the patentee "cooperates" by inventing. This binding commitment by users is fundamental to the patent system, and it directly implies that the patent system must be modeled as a cooperative game.

In contrast, the Swanson and Baumol model ignores this central feature of the patent system. As they acknowledge, their model is a purely static one, in which "all investments in R&D by the patent holders already have been sunk."[210] It is because of this assumption that each patentee is bid down to its incremental marginal value as compared with other patentees. But this assumption begs the central question of the patent system: why would anyone ever develop an invention knowing that they would not receive any reward? In effect, the auction model applies non-cooperative game theory to an incompletely specified game. If we were to try to model the patent system as a non-cooperative game, we would have to complete the backward induction process and ask whether the patentee would have had an incentive to invent the invention in the first place. As discussed in the main text, the answer is that they would not: the entire incentive system would degenerate into the defect/defect solution of the non-cooperative Prisoners' Dilemma, which is why the patent system cannot be modeled as a non-cooperative game.[211] On the other hand, if we treat the patent system as a cooperative game, we cannot accept Swanson and Baumol's premise that the inventor's costs are already sunk when the royalties are decided.

It is sometimes said that cooperative game solutions formalize notions of fairness and distributive justice, while non-cooperative games are concerned with efficiency.[212] That is misleading. While cooperative game theory does reflect a fairness concept, efficiency as a normative principle also relies ultimately on a particular notion of fairness, namely on the principle that a just reward to an input factor is its marginal productivity, as reflected in a competitive market paradigm.[213] And the

210. Swanson & Baumol, *supra* note 50, at 18.

211. *See supra* Part II.C.

212. *See, e.g.*, Layne-Farrar et al., *supra* note 14, at 685, 693 (describing the Swanson & Baumol model as being "rooted in the concept of economic efficiency," while cooperative game theory relates to "concepts of fairness").

213. *See, e.g.*, Young, *supra* note 113 ("In a perfectly competitive market, the wage of a laborer equals his marginal product. No ethical judgment need be made as to whether marginal productivity is a 'just' rule of compensation *so*

fairness principle underpinning the Shapley value as a solution concept for cooperative games is fundamentally the same, namely "the idea that rewards should be in proportion to contributions."[214] The difference is that cooperative game theory allows us to define what is meant by "marginal contribution" when outputs are superadditive. As H. Peyton Young has explained:

> In theory, marginal cost pricing is the only pricing mechanism that is consistent with economic efficiency in the large. Unfortunately it is typically unworkable as a cost allocation method because marginal costs need not sum to total costs, as required for an allocation. Indeed, marginal cost pricing may not even *cover* costs. This possibility arises in natural monopolies characterized by increasing returns to scale and declining marginal costs, such as distribution networks for transport, electric power, water, and communications services.[215]

The problem that marginal cost pricing may not cover costs because of increasing returns to scale is exactly the problem which justifies the patent system. It is the failure to cover costs, consequent on adoption of marginal cost pricing, which makes incremental ex ante pricing inadequate as an approach to FRAND royalties.

The early work on applications of Shapley value was explicitly concerned with efficient production in a decentralized firm with joint costs.[216] The magic of ideal markets generally is that individuals will make decisions that are socially optimal, based only on price information.[217] However, the classical market described by non-cooperative game theory fails when decisions by one player impose costs or benefits on another. Superadditive games are those in which the two players together produce more than the sum of what they can produce individually;[218] for example, any standard involving complementary patents is superadditive. Superadditive games cannot be optimally solved in a non-cooperative market because the synergy from the combination is an externality to each individual

long as competitive markets are accepted as the correct form of economic organization." (emphasis added)).

214. *Id.*

215. H.P. Young, *Producer Incentives in Cost Allocation*, 53 ECONOMETRICA 757, 757 (1985).

216. *See, e.g.*, Martin Shubik, *Incentives, Decentralized Control, the Assignment of Joint Costs, and Internal Pricing*, 8 MGT. SCI. 325, 326–28 (1962).

217. Of course real markets are never ideal, but nonetheless, that is the attraction.

218. *See* OSBORNE & RUBENSTEIN, *supra* note 113, at 258.

agent.[219] The market response is the firm, but the firm simply shifts the focus of the problem.[220] If the manager of the firm has full information about costs and benefits, she can simply order individual agents to act for the greater good of the firm as a whole, rather than in their narrow self-interest. But in any large firm higher-level managers will not have full information about each division. Information is often compressed through profit and loss statements based on decision centers within the firm, and the division is given direction through incentives provided by bonuses or increased resource allocation based on those statements. Thus there is a managerial problem of decentralized decision making: how to allocate resources among divisions so as to maximize the overall firm profit, while knowing only how each division's output contributes to the profit of the whole (but not the specifics about how each division is run). As Shubik notes, "An optimally decentralized system will have the property that the net effect of all individual actions will be more favorable to the firm than the actions selected by any other array of decision centers."[221] If, on the other hand, the wrong cost allocation method is chosen, "it is possible that individual rational action based upon the cost assignment may add up to corporate idiocy."[222] Thus, it is necessary to design a reward structure "so that the selection of choices which are best for the individual decision-maker will always coincide with those which are best for the organization,"[223] and "[a] goal of good management should be to design a reward system for those who take risks in making decisions in such a manner that the rewards to the individual correlate positively with the worth of the decision to the organization."[224] This is not a matter of fairness, but rather of corporate efficiency. A firm that rewards its subordinate decision-makers for contributing to the worth of the firm as a whole will eventually prevail over a firm that does otherwise.

219. *See id.*

220. *See* Ronald H. Coase, *The Nature of the Firm*, 4 ECONOMICA 386 (1937), *reprinted in* R.H. COASE, THE FIRM, THE MARKET, AND THE LAW 33 (1988).

221. *See* Shubik, *supra* note 216, at 329.

222. *Id.*

223. *Id.* at 328.

224. *Id.* at 325; *see also* Young, *supra* note 215 ("A reasonable goal of good management is to adopt a system of incentives that rewards individuals for making decisions that increase the firm's overall profits and penalizes decisions that damage profits.").

The patent system addresses what is fundamentally the same system of decentralized decision making with limited information. As is often noted, if the government knew what inventions would be best for society as a whole, it could simply fund them directly.[225] This corresponds to the situation where a manager has sufficient information to simply direct the employees to act optimally. This does occur sometimes, both for firms and governments, but it is not a general solution to the problem. The problem of FRAND royalties for complementary patented technologies is exactly analogous to the managerial problem of how to allocate resources so as to encourage decentralized decision makers to act for the benefit of the whole.

It is this problem which is solved by Shapley pricing.[226] As discussed in more detail below, Shapley value provides the only solution to this problem that is consistent with a few simple axioms. As such, it is "the natural interpretation[] of marginalism in problems of pure cooperation"[227] with transferable utility. Thus the difference between market efficiency and Shapley pricing is technical, not philosophical.

Consider a simple example which illustrates the problem that is addressed by Shapley pricing. Suppose *A* has a patented battery-saving technology covered by one patent and *B* has patented a cellular communication technology also covered by one patent, and these products are embodied in a smartphone. There is a user, *X*, who uses her phone while working out of the office visiting clients. The battery-saving technology is worth $1 on its own, because without the cellular communication capability the phone can only be used for playing games, while a phone with only the cellular technology is worth $10; but the two together are worth $15 because they allow the phone to be used for a full business day without recharging. Technology *A* adds $1 in combination with unpatented technologies, and $5 in combination with *B*. A full description of *A*'s marginal contribution to the value of the phone in the hands of *X* is ($1, $5), to reflect both of these possibilities. Now suppose there is another user, *Y*, who works in an office and who likes to play bat-

225. See *supra* note 100 for articles discussing the benefits of patents over prizes.

226. *See* Young, *supra* note 215 (motivating the discussion of Aumann-Shapley pricing, a generalization of Shapley pricing to continuous production functions, by focusing on "the incentives that different cost accounting methods create for the adoption of more efficient techniques of production").

227. Young, *supra* note 113, at 268.

tery-draining video games on his phone while commuting. For *Y*, the battery-saving technology is relatively more important, and the cellular communication is less important. Suppose that for *Y* the battery-saving technology is worth $2 on its own, the cellular technology is worth $7, and the two together are worth $13. The marginal contribution of technology *A* to user *Y* ($2, $6) is higher in all respects—both in combination with unpatented technology, and in combination with technology *B*—than for user *X*. On the other hand, the total value of the bundle to *Y* is less than for user *X*. The marginality principle says that the payoff to *A* from user *Y* should be higher than the payoff from user *X*, even though the technology as a bundle is worth less to *Y* than to *X*.[228] The intuition is that the marginal contribution made by the battery-saving technology to user *Y* is higher any way you look at it—whether relative to a system with or without cellular technology—so the incremental value of that technology to user *Y* must be higher than its incremental value to user *B*. This of course implies that the royalty that *Y* pays to *B* must be less than the royalty that *X* pays to *B* (though it does not imply that the royalty *Y* pays to *B* will be less than the royalty *Y* pays to *A*).

As a matter both of law and fairness we need to assess royalties that reflect the importance of each technology to the users, and ideally which reflect the technologies' marginal values. But it is not clear how to define the marginal value. Should we say that *A* should receive $5 from user *X* and $6 from user *Y*, because that is how much value *A* adds relative to *B* alone? That would imply that *B* would get $10 and $7, respectively. Or should we say that *B* should get $14 from *X* and $11 from *Y*, because that is how much *B* adds to *A* alone? That would imply that *A* gets $1 and $2, respectively, which is much less than if we look at it from A's perspective.

The Shapley value sharing rule (described in the main text)[229] is a solution to this problem that satisfies three intuitively appealing axioms: (1) symmetry; (2) full distribution; and (3) marginality.[230] The symmetry principle requires that players

228. *See* H.P. Young, *Monotonic Solutions of Cooperative Games*, 14 INT'L J. GAME THEORY 65, 81 (1985) (providing a definition of the marginality principle).

229. *See supra* Part II.E.

230. *See* Shapley, *supra* note 112, at 308–09. The Shapley value can be derived from a number of related sets of axioms. This particular axiomization is due to H.P. Young. Young, *supra* note 228; *see also* Young, *supra* note 215. We

who make the same contribution to the value of the standard (the payoff) must be treated in the same way.[231] A general problem with cooperative games is that coalitions may form solely in order to extract value from another player. For example, if the game has three players *A*, *B*, and *C*, all of whom can produce nothing individually, $10 in collaboration with one other player and $60 in collaboration with both other players, the intuitively fair solution would be that all three cooperate and each receives a payoff of $20. However, *A* and *B* might agree to present *C* with a take-it-or-leave-it offer in which *A* and *B* would cooperate with *C* only if *C* agreed to accept $12, while *A* and *B* each received $24. The symmetry axiom prohibits this kind of bargain. The full distribution axiom requires that the payoff is fully distributed: that is, the parties do not leave money on the table.[232] The third axiom, marginality, captures the notion that a player's payoff should depend only on its own marginal contribution to the overall output.[233] In a cooperative game, the player's marginal contribution is not a single number; it is described by the function or vector that describes the player's marginal contribution to all possible coalitions. The marginality principle says that if *A*'s marginal contribution increases in some respect, but does not decrease in any respect, then *A*'s royalty must increase.

It turns out that the Shapley value is the only sharing rule which satisfies all of these principles.[234] In our example, using Shapley pricing *A* would get $3 from user *X* and $4 from user *Y*, while *B* would get $12 and $9, respectively.[235] This seems intui-

use it because it relates naturally to the relevant legal principles. The full distribution axiom is often called "efficiency." The term "efficiency" is confusing, both because it does not mean the same thing as in the general economics literature and because it is not used consistently even in the cooperative game theory literature. We will therefore avoid it. Shapley's original principles were symmetry, the carrier axiom and additivity. Alvin E. Roth, *Introduction to the Shapley Value*, *in* THE SHAPLEY VALUE, *supra* note 113, at 1, 5. The carrier axiom (referred to by Shapley as "efficiency," but more commonly known as the carrier axiom) has two components, namely full distribution and the null player axiom. *Id.* For that reason the Shapley value is often characterized as being based on four axioms. *See, e.g.*, MICHAEL MASCHLER ET AL., GAME THEORY 749–51 (2013). Young's marginality axiom can be derived from additivity and the null player axiom. *See* Young, *supra* note 228, at 71.

231. *See* Shapley, *supra* note 112, at 309–10.

232. *See* Roth, *supra* note 230, (referring to full distribution as "efficient").

233. Young, *supra* note 113, at 268.

234. Roth, *supra* note 230.

235. This is a simplification. We endorse a bargaining model in which the

tively sound; *B* gets more from both *X* and *Y* than does *A*, because *B*'s technology is more important to both *X* and *Y*,[236] but *A* gets relatively more from *Y* than from *X* because *A*'s technology is relatively more important to *Y*. This, we suggest, reflects the legal principles that "the patentee's royalty must be premised on the value of the patented feature,"[237] and "a patent that is extremely important and central to the standard would reasonably command a higher royalty rate than a less important patent."[238]

In summary, the patent system and the FRAND rate setting process in particular should be understood as a cooperative game with transferable utility. The FRAND commitment by the patentee to the user is a commitment not to charge excessive royalties, but at the same time the patent system is a commitment by users to pay adequate royalties. We are seeking a solution which provides the patentee with the optimal incentive to invent; as with a traditional efficiency analysis, the incentive is both socially optimal and fair if it reflects the patentee's marginal contribution. This is reflected in the notion that underpins Shapley pricing, namely that "rewards should be in proportion to contributions," as well as in the legal principle that "the parties in a hypothetical negotiation would set RAND royalty rates by looking at the importance of the SEPs to the standard and the importance of the standard and the SEPs to the products at issue."[239] We therefore suggest that the FRAND

patentee is not necessarily entitled to the full social surplus attributable to its invention. Consequently, it is more precise to say that *A* would bargain with *X* over how to split the $3 marginal benefit attributable to *X*'s invention, and so on.

236. The marginal benefit of *B*'s technology to *X* is ($10, $14) and to *Y* is ($7, $11).

237. Ericsson, Inc. v. D-Link Sys., Inc., 773 F.3d 1201, 1232 (Fed. Cir. 2014).

238. Microsoft Corp. v. Motorola, Inc., No. C10-1823JLR, 2013 WL 2111217, at *20 (W.D. Wash. Apr. 25, 2013), *aff'd*, 795 F.3d 1024 (9th Cir. 2015).

239. *Id.* at *3; *see also In re* Innovatio IP Ventures, LLC Patent Litig., No. 11 C 9308, 2013 WL 5593609, at *10 (N.D. Ill. Oct. 3, 2013) ("Imagine, for example, that the court has determined that a given patent portfolio provides 25% of the functionality of a standard, and that the court is considering a proposed RAND rate based on that determination. Logically, the other standard-essential patents outside of the portfolio should comprise 75% of the value of the standard, or three times the value of the asserted portfolio."). The marginality principle excludes a sharing rule based on the number of patents held by a patentee. Numerical sharing would imply that *A* gets $7.50 from *X* but only $6.50 from *Y*, even though *A*'s technology is relatively more valuable to *Y*. Un-

royalty setting problem is properly conceptualized as a cooperative game, and Shapley pricing is the appropriate solution.

II. APPENDIX B

This Appendix addresses two technical questions, namely whether the hypothetical negotiation is carried out by individual users or by users as a group, and how to deal with ex ante competition to be included in the standard.

A. INDIVIDUAL OR GROUP NEGOTIATIONS?

In describing our approach in the main text we referred to the SSO negotiating with "users," with intentional ambiguity as to whether the negotiation would be with one user at a time, or with users as a group.[240] In our view, the correct approach in principle is that the negotiation is with one user at a time; each individual user bargains with each patentee to split the Shapley value of that patentee's contribution to the value of the standard in the hands of that particular user.[241] This is consistent with the case law, which indicates that the royalty should reflect the value of the patent to the standard as well as the value to the particular user. But the value of the patent to the standard has no independent content; it is nothing but the aggregate of the value of the patent to all the individual users. Consequently, considering the value of the standard to each

der numerical sharing, *A*'s royalty does not depend on its own merits alone; *A* suffers because *B*'s technology is less valuable. Consistent with the marginality principle, the case law on proportionality rejects numerical sharing, at least in principle. *See id.* at *10 ("In making this determination, the court notes that it is not appropriate to determine the value of the non-asserted standard-essential patents based merely on numbers. If a patent holder owns ten out of a hundred patents essential to a given standard, it does not automatically mean that it contributes 10% of the value of the standard."); *id.* (emphasizing that a "commonly understood principle of proportionality [is] that [c]ompensation under [RAND] must reflect the patent owner's proportion of all essential patents," and that "[t]his is not simply a numeric equation but the compensation must, within reasonable bounds, reflect the contribution" (citing *Microsoft*, 2013 WL 2111217, at *12)).

240. *See supra* note 151 and accompanying text.

241. Gregory Sidak argues that it is wrong to treat the hypothetical negotiation as being between one SEP holder and a solitary representative of all implementers because this gives monopsony power to the implementers. *See* Sidak, *supra* note 14, at 985. Our argument towards the same conclusion does not turn on monopsony power, however. While we agree that it would be wrong to credit the implementers with monopsony power, because the negotiation is hypothetical we could posit a negotiation with a single representative user, simply by not crediting that user with monopsony power.

user individually ensures that the reward to the patentee is commensurate with both the value to the user and the value to the standard.

With that said, looking to the value of the patent to the standard might well have practical merit in a particular case if, for example, there is good evidence that the technology in question was of little importance to the standard, and that the defendant is a more or less average user. That is, looking to the value of the patent to the standard may, given the evidence, be a good proxy for looking to the value of the standard to the particular user.[242] On the other hand, given the individualized nature of patent litigation, there will often be direct evidence about the value of the patented technology to the particular user, in which case consideration of the value of patent to the technology can simply be ignored. To give independent content to the value of the patent to the standard would imply that if a patent was valuable to the standard (which presumably means it is valuable to most users), but worthless to a particular user, that particular user might be liable to pay a substantial royalty (though presumably somewhat less than the average user). We see no particular merit in such a rule.

Our approach does imply that users for whom the standard is equally valuable will pay the same royalty, but users who value the standard differently may pay different amounts. There is some debate in the literature as to whether the "nondiscriminatory" part of FRAND means that all users must pay the same amount, or only that similarly situated users must pay the same amount.[243] We adopt the latter view. This is consistent with the user apportionment principle set out in the case law, which specifies that the royalty must reflect the usefulness of the patent to the particular user, as well as to the standard.[244] It is also efficient, because it amounts to allowing perfect price discrimination between users. However, if the view ultimately prevails that "nondiscriminatory" means that one royalty is charged to all users, this can be modeled in our approach by a game in which the users are represented by a

242. *See Innovatio*, 2013 WL 5593609, at *8 (considering only the value to the standard on the basis that this also reflects the value to the user).

243. *See* Carlton & Shampine, *supra* note 42, at 545–46 (reviewing the debate among economists regarding application of the nondiscriminatory principle).

244. See *supra* notes 149–50 and accompanying text for a discussion of the relevant legal rules.

single user, who values the standard in a way that reflects some kind of general preferences of the users.[245]

B. THE IMPACT OF EX ANTE COMPETITION

A second technical issue is how our model deals with ex ante competition to be included in the standard. The incremental ex ante principle that we have critiqued in the main text[246] can be understood as a particular form of a broader principle that competition will constrain the amount a patentee can charge ex ante, but once the standard is adopted, that constraint is eliminated. Swanson and Baumol's auction model is in turn a particular instantiation of the incremental ex ante principle, which we have argued is unsound, in part because it effectively treats patented alternatives as unpatented.[247] On the other hand, we agree that a reasonable royalty should be capped by the incremental value of the patented technology as compared with the best *un*patented technology that could have been incorporated into the standard. That view effectively ignores patented alternatives entirely. This raises two questions. First, how does the use of unpatented alternatives as a cap on the value of the patented technology emerge from our framework? It might be said that if the negotiation takes place contingent on the ex post information as to what technology has been selected to be part of the patent, then the user cannot credibly threaten to switch to an unpatented technology, any more than it can threaten to switch to an alternative patented technology, because either case would require the user to give up the benefits of standardization. Second, there is evidently a middle ground between treating patented alternatives as if they were unpatented, and ignoring them entirely. We have argued that a negotiation model is preferable to Swanson and Baumol's auction model;[248] and we acknowledged that in general, outside the standards context, the presence of patented alternatives is likely to affect the royalty received by the chosen patentee, even if it does not result in the royalty being driven down to zero.[249] How does this fit with our ex post framework?

245. How exactly the users' preferences should be aggregated is a difficult question which we will not deal with, as we are not sympathetic to this interpretation of the "nondiscriminatory" requirement.

246. *See supra* Part III.A.

247. *See supra* Part II.

248. *See supra* Part II.D.

249. In *Innovatio*, Judge Holderman rejected the auction model, on the ba-

We must always keep in mind that our contingent ex ante framework is simply a mechanism for determining a reasonable royalty. We have pointed out that the traditional ex ante framework should not be taken literally; simply because the negotiation is assumed to take place ex ante, it should not be automatically assumed that the parties only have ex ante information.[250] The ex ante nature of the negotiation is a construct used to ensure that the patentee cannot extract sunk costs, which would otherwise distort user and patentee incentives. Our contingent ex ante framework is similarly a mechanism which is used to ensure the appropriate incentive.

On the first point, the use of unpatented alternatives is necessary to ensure that the patentee does not capture more than the value of the previously existing technology. This is the general argument for capping a reasonable royalty at the value of the best noninfringing alternative. Consequently, the argument that in a truly ex post approach the user would not be able to switch to an unpatented alternative is beside the point. An ex post informational framework is not desirable in itself; it is desirable because it implements sound policy objectives. If the availability of an unpatented alternative does not emerge naturally from considering a contingent ex post hypothetical negotiation, then we will build it in. And it is very easy to build in; when the Shapley value is assessed, we need only assume that all unpatented technologies are "in the room" from the outset. So, if the standard consists of a single patented technology which is no better than an unpatented alternative, the Shapley value for that technology would be zero, because it does not provide any incremental benefit over the best technology that could have been implemented using all the technologies "in the room" prior to the entry of the patented technology. Similarly, suppose that patented technology A is necessary to implement the standard (e.g., WLAN transmission capability), and another technology adds value (e.g., battery saving functionality). If a patented technology B is used to implement the battery saving functionality, but there is an unpatented tech-

sis that it is not plausible that competition between patentees would result in them bargaining down to zero, but he nonetheless apparently accepts in principle that ex ante competition would drive down the royalty to some degree (though that was not a factor on the facts). *In re* Innovatio IP Ventures, LLC Patent Litig., No. 11 C 9308, 2013 WL 5593609, at *20 (N.D. Ill. Oct. 3, 2013).

250. See *supra* note 120 and accompanying text for a discussion of knowledge in our model.

nology that would serve equally well, the incremental value added by technology B is always zero, regardless of the order in which it is added to the mix of technologies, and so its Shapley value is zero.

The second problem (regarding the existence of patented alternatives) is more subtle. One question is how, technically, the effect of ex ante competition could be incorporated into our model. The second, more difficult question, is whether it is desirable to allow the ex ante competition to affect the reasonable royalty.

The answer to the technical question is reasonably straightforward: the presence of ex ante competition should be reflected in increased bargaining power for the user in the contingent ex ante negotiation. To begin, consider an example from outside the SEP context. Suppose that Cialis and Viagra are perfect substitutes for treating erectile dysfunction. Under Swanson and Baumol's auction model, the price of either would be zero, because one could be played off against the other. We have argued that this is unsound in terms of dynamic efficiency, and implausible in practice.[251] However, it is entirely plausible that the price that Pfizer can charge for Viagra in the presence of competition from Cialis is less than it would be if Viagra were the only product in its class. In a negotiation model, the effect of competition between Cialis and Viagra is to increase the user's bargaining power. Using arbitrary numbers to illustrate, if only Viagra is available, and it is worth $100 to the user, and the user and Pfizer have equal bargaining power, the user will pay $50. If Cialis is then developed, it is not plausible that the price for Viagra would drop to zero, as the auction model or Bertrand competition implies, but it is plausible that it would drop as compared with the monopoly price, say to $40.[252]

To extend this to the SEP context, suppose there are two equivalent patented technologies, *A* and *B*, which are competing to be part of the standard. Even if *A* is selected, it seems plausible that the price that could be demanded by *A* would be depressed by ex ante competition from *B*, in the same way that the price that can be demanded by Viagra is depressed by ex post competition from Cialis. In our contingent ex ante model,

251. *See supra* Part II.C.

252. This does not imply any particular model of duopoly competition, such as Cournot competition.

the users are assumed to bargain with the successful patentee, *A*, with knowledge that *A* has been selected, so that users cannot use the threat of switching to *B* to drive down the price.[253] In this model the presence of ex ante competition by *B* can be reflected by increasing the user's bargaining power relative to a case in which there was no ex ante competition. If there is only one WLAN technology, *A*, worth $100 to the user, and the user and *A* have equal bargaining power, the user will pay $50. If we now suppose that ex ante there was another equivalent technology, *B*, that could have been included into the standard that would have depressed the price that could be demanded by *A*, this can be reflected by increasing the user's bargaining power in the ex post negotiation, even though the parties are assumed to know that *A* has been chosen, so that the user cannot threaten to switch to *B*. It may be said that this smuggles ex ante competition into our ex post model. If so, we are unconcerned. Again, our model is a conceptual mechanism for determining a reasonable royalty. We are not concerned if the construction of the hypothetical negotiation has some constraints that appear ad hoc in terms of how a contingent ex ante negotiation might be said to proceed, so long as they are those constraints are sound as a matter of policy. After all, it has always been recognized that the standard hypothetical negotiation is artificial, since in many cases the parties in question would never actually have negotiated ex ante.[254]

With that said, we would point out that the use of a contingent ex ante negotiation really addresses two functional points. First, that the negotiation takes place ex ante is used to ensure that the patentee cannot extract sunk costs. Second, that the parties are assumed to have ex post information—they know which technology has been selected—is used to ensure that incentive to invent is appropriate, by ensuring that the patentee whose patents are actually infringed is in a position to demand a royalty. The same goals could be achieved by making the converse assumptions: the hypothetical negotiation takes place ex post, but in the absence of user sunk costs. In that case, patentee *A*, whose patent was actually infringed, would be entitled to the full royalty, but the assumption that the user has no

253. *See supra* Part III.A.

254. *See, e.g.*, John C. Jarosz & Michael J. Chapman, *The Hypothetical Negotiation and Reasonable Royalty Damages: The Tail Wagging the Dog*, 16 STAN. TECH. L. REV. 769, 799–803 (2013) (describing the value of ex ante and ex post knowledge in hypothetical negotiations).

sunk costs means that the user could credibly threaten to switch to another standard, including another patented standard, if *A* demanded too much. In this model, the ex post competition from alternative standards would limit the patentee's bargaining power in exactly the same way that the availability of Cialis limits Pfizer's bargaining power. The impact of competition on the user's bargaining power may seem to emerge more naturally from this model, but it is equivalent to the contingent ex ante model.

The more difficult question is whether ex ante competition should be taken into account at all. While it is intuitive to say that the extent of ex ante competition should constrain the royalty, even if it does not drive the price to zero, the efficiency argument for this position is not clear. As discussed above, all that is required from a static efficiency perspective is that the reasonable royalty is less than the ex ante value of the technology (that is, excluding sunk costs) to the user as compared with the best unpatented alternative.[255] That condition is satisfied even if ex ante competition is not taken into account at all, because in a contingent ex ante negotiation the user will not agree to pay more than the value of the technology excluding sunk costs, even if there is only one patented choice for the standard. From a dynamic efficiency perspective (the incentive to invent), a reasonable royalty must be greater than the marginal cost and less than the full social surplus. Again, the reasonable royalty determined in a contingent ex ante negotiation will satisfy that criterion even if patented competition is ignored entirely.

As discussed above, to take ex ante competition into account in a negotiation model (that is to say, without driving the royalty down to zero, as in the auction model), would shift the bargaining power in favour of the user. But as we have noted, there is no satisfactory theory of the optimal return to a patentee, and in the absence of such a model we cannot say whether that shift would be optimal in theory.

Because of the absence of a good theory of the optimal return to a patentee, we took the return to a similarly situated patentee to be the appropriate benchmark. The question then is what counts as a similarly situated patentee? In general, competing patented technologies arise because different inventors

255. *See supra* Part II.B.

are trying to solve the same problem.[256] This is part of the patent race problem, which manifests itself partly in increased costs of invention, as various parties seek to be first, but also in increased competition and reduced profits within a class of products.[257] Because the problem is a general one, we might say that the appropriate benchmark is competing patents outside the standards context, such as Viagra and Cialis. If the return to Viagra is in fact affected by competition from Cialis, and vice versa, then if there is similar competition to develop technology intended for a standard, the return to the successful patentee should be similarly reduced to reflect that competition, or inventors racing to be part of a standard will receive a higher payoff than inventors racing to be capture a non-standardized market.

The other salient comparison is with an invention that becomes a de facto standard by virtue of being first to market. If technology *A* captures the market, the difficulty of switching means that the royalty that *A* can charge will not be reduced even if equivalent technologies are subsequently developed. Put another way, because of the nature of the market for a standard, ex post competition from equivalent products will not depress royalties in the same way as in a market without network effects.

In our view, it is preferable to ignore the effect of ex ante competition on price. While it is appealing to imagine ex ante price competition (even contingent ex ante competition, as in our model), price competition is not in fact a part of the process of developing a standard.[258] In our view, that is for the best. Apart from concerns about antitrust violations if pricing were to be discussed during the standard development process, the technical task of developing a sound standard is difficult enough as it is, which is why the engineers prefer to be able to

256. *See, e.g.*, Carl Shapiro, *Patent Licensing and R&D Rivalry*, 75 AM. ECON. REV., 25, 29–30 (1985).

257. The patent race literature normally emphasizes costs, because the usual model is one in which the inventors are competing to develop exactly the same invention, leading to a winner-take-all race. More realistically, in many cases the competing inventors will develop inventions which are patentably distinct yet close substitutes. In such cases, the competition will raise costs, as in the classic patent race, but will also depress profits.

258. *See, e.g.*, NAT'L RESEARCH COUNCIL OF THE NAT'L ACADEMIES, PATENT CHALLENGES FOR STANDARD-SETTING IN THE GLOBAL ECONOMY 60 (Keith Maskus & Stephen A. Merrill eds., 2013) ("[F]ew SSOs have adopted policies with regard to *ex ante* disclosure of licensing terms.").

do so based on purely technical considerations. Apart from these practical considerations, there are theoretical objections to allowing price competition in the standard setting process. It might mean an inferior standard would be adopted. This would be desirable only if the deadweight loss from increased adoption due to the higher price for the technically superior standard at a higher price more than outweighed the increased consumer surplus due to the technical superiority. Whether that is true is an empirical question which depends on the particular markets and the exact price reduction at issue. It would be impossible to assess with the requisite degree of certainty during ex ante negotiations. For that reason, we think the current approach of focusing on the technical aspects of the standard is sound.

Ignoring ex ante competition implies that the appropriate comparison is with an invention that becomes a de facto standard. In our view, this is also appropriate because it avoids distorting the standards process. If a de facto standard was able to charge a price unconstrained by the threat of a switch to a competing standard, while a formal standard was so limited, this would provide an incentive to avoid formal standards, even when formal standards might be more efficient and provide for earlier standardization.

In summary, while there is considerable intuitive appeal to imagining that royalties would be constrained by ex ante competition, there is no reason to believe that constrained royalties would be superior in terms of either static or dynamic efficiency. The question should therefore turn on what is the appropriate real-world benchmark for a patent that has been selected to be included in a standard. In our view, the appropriate benchmark is the situation of a patentee with a de facto standard which emerged in the absence of competition, because this benchmark ensures that the choice between a de facto standard and a formal standard is financially neutral.