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Self-Replicating Technologies

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SELF-REPLICATING TECHNOLOGIES

Jeremy N. Sheff*

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ABSTRACT

Self-replicating technologies pose a challenge to the legal regimes we ordinarily rely on to promote a balance between innovation and competition. This Article examines recent efforts by the federal courts to deal with the leading edge of this policy challenge in cases involving the quintessential self-replicating technology: the seed. In a recent series of cases involving the invocation of the patent exhaustion defense by purchasers of Monsanto's "Roundup-Ready" genetically engineered herbicide-resistant crop technologies, farmers have argued that Monsanto's patent rights do not extend to the second generation of soybeans grown from a patented first-generation seed. In each case, the Federal Circuit found for Monsanto and against the farmers. The Supreme Court is about to take up the issue for the first time.

In this Article, I argue that the Federal Circuit reached the right result in the Roundup-Ready cases, but that it failed to articulate a satisfactory justification for its decisions. That justification, I claim, should be that the patent-based policy set by the Federal Circuit is preferable to alternative legal regimes—such as trade secret and contract law—because it avoids disincentives to competition, innovation, and dissemination of new self-replicating technologies while reducing transaction costs inherent in their commercialization. Importantly, however, not all self-replicating technologies are identical, and a categorical rule exempting them from patent exhaustion doctrine is unwarranted. I propose instead that application of the exhaustion doctrine should depend on the patentee's ability to charge supracompetitive prices in its primary market where consumers are able to substitute secondary-market embodiments.

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INTRODUCTION.....	230
I. PATENT EXHAUSTION: THE FIRST SALE DOCTRINE.....	232
II. ROUNDUP-READY ROUNDUP.....	235
A. <i>The Federal Circuit's Approach</i>	235
B. <i>Tensions With (and Within) Supreme Court Precedent</i>	238
III. A FUNCTIONAL APPROACH TO SELF-REPLICATING TECHNOLOGIES.....	240
A. <i>Self-Replication and Self-Disclosure</i>	241
B. <i>Qualifications and Objections</i>	247
IV. SUBSTITUTION AND THE COPYRIGHT ANALOGY: BALANCING INCENTIVES AND ACCESS.....	250
CONCLUSION.....	256

INTRODUCTION

Most can raise the flowers now,
For all have got the seed.¹

Self-replicating technologies, once the subject of theory² and fantasy,³ are now upon us. The original self-replicating machine—the living organism—has already been harnessed by biotechnology engineers and, more to the point, their patent lawyers.⁴ The next wave of self-replicating technologies, be they nanorobots or organic computers, are not far behind.⁵ Rather than triggering a “gray goo” apocalypse,⁶ these technologies are, at present, raising far more prosaic issues of intellectual property and antitrust law. In particular, they are challenging businesses, lawyers, and judges to establish a policy framework that will appropriately balance innovation with competition, allowing self-

1. Alfred Lord Tennyson, *The Flower*, in THE WORKS OF ALFRED LORD TENNYSON POET LAUREATE 230 (New York, The MacMillan Company 1901) (1884).

2. See generally, e.g., JOHN VON NEUMANN, THEORY OF SELF-REPRODUCING AUTOMATA (Arthur W. Burks ed., 1966).

3. See generally, e.g., *BATTERIES NOT INCLUDED (Universal Pictures 1987).

4. See generally, e.g., *Diamond v. Chakrabarty*, 447 U.S. 303 (1980) (engineered bacteria); *Elan Pharms., Inc. v. Mayo Found. for Med. Educ. & Research*, 346 F.3d 1051 (Fed. Cir. 2003) (transgenic mouse).

5. See generally Tong Wang et al., *Self-Replication of Information-Bearing Nanoscale Patterns*, 478 NATURE 225 (2011), available at <http://www.nature.com/nature/journal/v478/n7368/full/nature10500.html>; Robert A. Freitas, Jr., *Current Status of Nanomedicine and Medical Nanorobotics*, 2 J. OF COMPUTATIONAL & THEORETICAL NANOSCIENCE 1 (2005).

6. K. ERIC DREXLER, ENGINES OF CREATION 2.0: THE COMING ERA OF NANOTECHNOLOGY 354-55 (20th Anniversary ed. 2006) (“[A]ssembler-based replicators will therefore be able to do all that life can, and more. From an evolutionary point of view, this poses an obvious threat . . . [E]arly assembler-based replicators could beat the most advanced modern organisms. ‘Plants’ with ‘leaves’ no more efficient than today’s solar cells could out-compete real plants, crowding the biosphere with an inedible foliage. Tough, omnivorous ‘bacteria’ could out-compete real bacteria: they could spread like blowing pollen, replicate swiftly, and reduce the biosphere to dust in a matter of days. Dangerous replicators could easily be too tough, small, and rapidly spreading to stop—at least if we made no preparation . . . Among the cognoscenti of nanotechnology, this threat has become known as the ‘gray goo problem.’”).

replicating technologies to be efficiently developed and commercialized for the benefit of society.

This Article examines recent efforts by the federal courts to deal with the leading edge of this policy challenge in cases involving the quintessential self-replicating technology: the seed. In a recent series of cases involving Monsanto's "Roundup-Ready" genetically engineered herbicide-resistant crop technologies, the U.S. Court of Appeals for the Federal Circuit has been steadily charting the boundary between patent and antitrust principles as applied to self-replicating technologies. In each of the Roundup-Ready cases, a farmer has argued that Monsanto's patent rights do not extend to the second generation of soybeans grown from a patented first-generation seed. In each case, the Federal Circuit found for Monsanto and against the farmer.⁷ In its October 2012 Term, the Supreme Court of the United States will take up the issue for the first time.⁸

The Roundup-Ready cases are a harbinger of things to come. A number of similar herbicide-resistant crops are in the pipeline of the largest agribusiness concerns,⁹ and other self-replicating technologies lie just over the horizon.¹⁰ Moreover, these cases offer a useful lens on the economic issues presented by self-replicating technologies in general and the efforts to incentivize their creation and commercialization through law. While Monsanto's genetically engineered crop technologies present a host of complex policy issues,¹¹ in this Article, I will address only the specific issue of patent exhaustion addressed by the Federal Circuit's decided cases. Specifically, I will argue that the Federal Circuit reached the right result in the Roundup-Ready cases, but that it failed to articulate a satisfactory justification for its decisions. That justification, I claim, should be that the patent-based policy set by the Federal Circuit is preferable to alternative legal regimes—such as trade secret and contract law—because it avoids disincentives to competition, innovation, and dissemination of new self-replicating technologies while reducing transaction costs inherent in their

7. *Monsanto Co. v. Bowman*, 657 F.3d 1341, 1348 (Fed. Cir. 2011), *cert. granted*, 133 S. Ct. 420 (U.S. Oct. 5, 2012) (No. 11-796); *Monsanto Co. v. Scruggs*, 459 F.3d 1328, 1336 (Fed. Cir. 2006); *Monsanto Co. v. McFarling (McFarling II)*, 363 F.3d 1336, 1343-44 (Fed. Cir. 2004); *Monsanto Co. v. McFarling (McFarling I)*, 302 F.3d 1291, 1296-99 (Fed. Cir. 2002).

8. Order Granting Writ of Certiorari, *Bowman v. Monsanto Co.*, 133 S. Ct. 420 (U.S. Oct. 5, 2012) (No. 11-796), *available at* <http://www.supremecourt.gov/Search.aspx?FileName=/docketfiles/11-796.htm>.

9. Andrew Pollack, *A Battle Over an Engineered Crop*, N.Y. TIMES, Apr. 26, 2012, at B1, *available at* <http://www.nytimes.com/2012/04/26/business/energy-environment/dow-weed-killer-runs-into-opposition.html>.

10. *See sources cited supra* notes 5-6.

11. Many other issues, such as how to prevent or deal with the escape of engineered genetic material into non-engineered crop populations, monopolization of the seed market itself, potential restrictions of follow-on innovations, and the related problem of evergreening, are explored in Daryl Lim, *Rebooting the Bean*, ABA Section of Antitrust Law, Agriculture and Food Committee Bulletin (Fall 2012), at 2, *available at* <http://ssrn.com/abstract=2163220>.

commercialization. Importantly, however, this policy analysis also requires us to recognize that not all self-replicating technologies are identical, and thus that a categorical rule exempting them from patent exhaustion doctrine is unwarranted. I propose instead that application of the exhaustion doctrine should depend on analysis of the relationship between demand for first-generation embodiments of a self-replicating technology and demand for subsequent-generation embodiments, and particularly the patentee's ability to charge supracompetitive prices in its primary market where consumers are able to substitute secondary-market embodiments. This understanding of the stakes of patent exhaustion doctrine illuminates not only its application to self-replicating technologies, but its application to patented technologies in general.

This Article proceeds as follows. Part I provides relevant background on the law of patent exhaustion and its complicated relationship to both innovation and competition policy. Part II describes the case study of self-replicating technology provided by Monsanto's technology and the judicial decisions adjudicating its intellectual property rights with respect to that technology. Part III critiques the Federal Circuit's explanation that its rulings were designed to prevent "eviscerat[ion]" of patents in self-replicating technology by exploring two alternative policy regimes under which such technologies might be commercialized—trade secret and contract regimes—and discussing the likely effects for innovation and competition of channeling inventors of self-replicating technologies into such alternative regimes. Finding these alternative regimes unsatisfactory, Part IV goes on to examine the features of self-replicating technologies that are likely to channel innovators out of the patent regime and into those unsatisfactory alternatives—principally the ability to substitute a subsequent-generation embodiment for a first-generation embodiment—and generalizes from this analysis to draw lessons about the appropriate scope of patent exhaustion doctrine in general. I ultimately argue that the applicability of the exhaustion defense ought to depend on judgments about the appropriate balance between maintaining the incentive to innovation afforded by the ability to charge a monopoly price for a patented technology and ensuring access to such technologies for those who are unable to pay that monopoly price. Inevitably, such judgments will entail fact-specific sensitivity to both the nature of individual patented technologies and to the structure of demand for them.

I. PATENT EXHAUSTION: THE FIRST SALE DOCTRINE

A patent gives its holder the "right to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States."¹² But there are limits to the patentee's ability to enforce this exclusionary right, some grounded in concerns over competition policy. For example, the patent misuse doctrine "forbids the

12. 35 U.S.C. § 154(a)(1) (2012).

use of [a] patent to secure an exclusive right or limited monopoly not granted by the Patent Office and which it is contrary to public policy to grant.”¹³ Most commonly, this doctrine has been invoked to condemn particular tying arrangements and as such has been modified by statute to align it (in part) with prevailing principles of antitrust law.¹⁴ The doctrine of patent exhaustion, or first sale doctrine,¹⁵ “provides that the initial authorized sale of a patented item terminates all patent rights to that item.”¹⁶ It, too, has been identified with competition policy, although current Supreme Court jurisprudence leaves the fit between exhaustion and relevant antitrust doctrines open to question.¹⁷ Finally, antitrust law in general remains applicable to the practices of those who trade in patented technology—particularly as applied to licensing agreements, which are governed not only by patent law but by contract law.¹⁸

Patent law’s first sale doctrine is currently in an uncertain state, with the Federal Circuit and the Supreme Court (to say nothing of those courts’ observers) disagreeing on its scope. Within Supreme Court jurisprudence, there is a distinction between the right to use and the right to make a patented invention. While the patentee relinquishes the right to control the *use* of a patented article upon selling it, such a sale does not authorize the purchaser to *make* a newly infringing article—a principle that has historically arisen when the purchaser (or another downstream actor) repairs or refurbishes the article.¹⁹ Moreover, to trigger patent exhaustion a sale of a patented article must be “authorized,” a requirement that some patentees have successfully contracted

13. *Morton Salt Co. v. G. S. Suppiger Co.*, 314 U.S. 488, 492 (1942).

14. 35 U.S.C. § 271(d) (2010); see generally Robin C. Feldman, *The Insufficiency of Antitrust Analysis for Patent Misuse*, 55 HASTINGS L.J. 399 (2003) (arguing that the innovation policies underlying patent misuse are not entirely coextensive with antitrust policy, and particularly not with rule of reason analysis given the prerequisite of market power for a finding of liability). For an overview of the history and policy of patent misuse doctrine, see generally Christina Bohannon, *IP Misuse as Foreclosure*, 96 IOWA L. REV. 475 (2010).

15. This Article will use the terms “patent exhaustion” and “first sale” interchangeably.

16. *Quanta Computer, Inc. v. LG Electronics, Inc.*, 553 U.S. 617, 625 (2008); see also *Adams v. Burke*, 84 U.S. (17 Wall.) 453, 456 (1873) (“[W]hen the patentee, or the person having his rights, sells a machine or instrument whose sole value is in its use, he receives the consideration for its use and he parts with the right to restrict that use.”); *Bloomer v. McQuewan*, 55 U.S. (14 How.) 539, 549 (1852) (“And when the machine passes to the hands of the purchaser, it is no longer within the limits of the monopoly.”).

17. See generally Herbert Hovenkamp, *Post-Sale Restraints and Competitive Harm: The First Sale Doctrine in Perspective*, 66 N.Y.U. ANN. SURV. AM. L. 487 (2011). Similar doctrines apply in copyright and trademark law. 17 U.S.C. § 109 (2008) (codifying the copyright first sale doctrine); *Prestonettes, Inc. v. Coty*, 264 U.S. 359 (1924) (establishing the trademark first sale doctrine).

18. See generally HERBERT HOVENKAMP ET AL., *IP AND ANTITRUST* (2d ed. 2010).

19. *Aro Mfg. Co., Inc. v. Convertible Top Replacement Co.*, 365 U.S. 336, 342-46 & n.9 (1961); cf. *Am. Cotton-Tie Co. v. Simmons*, 106 U.S. 89 (1882) (finding refurbishment of used and severed patented cotton bale ties marked with a “use once only” restriction to be an infringement, without discussing the first sale issue).

around using license restrictions. Thus, where a patentee licenses a manufacturer to produce articles under its patent but limits that license's scope, the manufacturer's sale of an embodiment of the patent outside of that scope is "unauthorized." Such sales will not exhaust the patentee's rights as to those articles, at least where the purchaser was on notice of the breach of the license.²⁰

Over the past two decades, the Federal Circuit has taken this restricted license exception to the first sale doctrine one step further, extending it to end users of patented inventions. The mechanism for this extension is the "conditional sale" doctrine, under which post-sale restrictions imposed on a patented article under a contract with the end user of the article (as opposed to a licensed manufacturer or other intermediary) can prevent exhaustion of the patentee's rights with respect to that article. So, for example, in *Mallinckrodt, Inc. v. Medipart, Inc.*, where a patentee transferred possession of a patented medical device to a hospital pursuant to a label license providing that the device was for "single use only," the court held that reuse of the device constituted not just a violation of the license terms (i.e., breach of contract), but also could potentially constitute patent infringement.²¹ The Federal Circuit relied on numerous patent misuse cases to conclude that "not all restrictions on the [post-sale] use of patented goods are unenforceable"²² and reasoned that such restrictions could likewise be used to limit the first sale doctrine. In so doing, the Federal Circuit seemed to be attempting to align the first sale doctrine with rule-of-reason analysis under antitrust law, following a similar effort with respect to patent misuse doctrine.²³

Recently, the Supreme Court has pushed back on the Federal Circuit's "conditional sale" doctrine and the resulting pressure on the first sale doctrine. In *Quanta Computer, Inc. v. LG Electronics, Inc.*,²⁴ the Supreme Court clothed its reversal of the Federal Circuit's opinion in broad language that appeared inconsistent with the conditional sale doctrine of *Mallinckrodt*.²⁵ However, the holding in *Quanta* was grounded in the particular facts of the license agreements at issue in that case, which the Supreme Court interpreted to create unconditional sales.²⁶ The result was, in some commentators' view, a missed

20. *Gen. Talking Pictures Corp. v. W. Elec. Co.*, 304 U.S. 175, 181-82 (1938), *aff'd on reh'g*, 305 U.S. 124 (1938).

21. *Mallinckrodt, Inc. v. Medipart, Inc.*, 976 F.2d 700, 709 (1992).

22. *Id.* at 703-06.

23. *Id.* at 706; *cf.* sources cited *supra* note 14.

24. 553 U.S. 617 (2008).

25. *Id.* at 638 ("The authorized sale of an article that substantially embodies a patent exhausts the patent holder's rights and prevents the patent holder from invoking patent law to control postsale use of the article."); *see also* Hovenkamp, *supra* note 17, at 501 & nn.60, 64; *Static Control Components, Inc. v. Lexmark Int'l, Inc.*, 615 F.Supp.2d 575, 585-86 (E.D. Ky. 2009) ("*Quanta* overruled *Mallinckrodt sub silentio*. The Supreme Court's broad statement of the law of patent exhaustion simply cannot be squared with the position that the *Quanta* holding is limited to its specific facts.>").

26. *Quanta*, 553 U.S. at 635-37.

opportunity: an apparent but indirect rejection of the Federal Circuit's rule-of-reason approach without any guidance as to the appropriate relationship between first sale doctrine and competition (or innovation) policy.²⁷

There are thus at least two important distinctions on which current patent exhaustion doctrine turns: between "using" and "making" an invention, on the one hand, and between conditional *licenses* and conditional *sales*, on the other. The use/make distinction can be derived entirely from Supreme Court precedent, while the license/sale distinction represents a possible divergence between Supreme Court and Federal Circuit precedent. Each of these distinctions turns out to be highly formalistic in practice and can destabilize as market actors innovate not only their technologies, but also their business strategies for exploiting and commercializing those technologies. Self-replicating technologies in general, and the Roundup-Ready cases in particular, highlight this doctrinal instability, as the next Part demonstrates.

II. ROUNDUP-READY ROUNDUP

A. *The Federal Circuit's Approach*

Monsanto is a manufacturer and former patentee²⁸ of a potent herbicide—glyphosate—that it markets under the brand name "Roundup."²⁹ Glyphosate operates by inhibiting the operation of an enzyme essential to the production of amino acids in plants.³⁰ Monsanto has also engineered a variant gene that can produce a glyphosate-tolerant version of the inhibited enzyme and has obtained patent protection for the modified gene, plants and plant cells that incorporate the modified gene, and related genetic engineering technologies necessary to the production of plants and seeds composed of those cells.³¹ Monsanto markets seeds for glyphosate-tolerant crops under the "Roundup-Ready" brand name.³²

Roundup-Ready seeds are produced either by Monsanto itself or by independent seed manufacturers operating under license from Monsanto. Under such a license, seed manufacturers obtain the right to insert the chimeric Roundup-Ready gene into the germplasm of their own seeds (allowing their seeds to express the glyphosate-resistant trait), subject to two conditions. First, they must pay Monsanto a royalty for every bag of seed they sell. Second,

27. Hovenkamp, *supra* note 17, at 491.

28. U.S. Patent Nos. 3,977,860 (filed June 11, 1973), 3,799,758 (filed Aug. 9, 1971).

29. Monsanto, THE HISTORY OF ROUNDUP (last visited Feb. 16, 2013) <http://www.monsanto.com/weedmanagement/pages/history-roundup-ready.aspx>.

30. *Id.*

31. U.S. Patent Nos. 5,352,605 (filed Oct. 28, 1993), 5,633,435 (filed Sept. 13, 1994). A description of the development of these technologies into commercial-scale seed production can be found in *Monsanto Co. v. Scruggs*, 342 F. Supp. 2d 584, 586-88 & nn.1-2 (N.D. Miss. 2004).

32. Monsanto, *supra* note 29.

every such sale of seed must be made pursuant to a “Technology Agreement” with the purchaser, rather than as an unconditional sale of the chattels themselves. In other words, every farmer who wants to buy Roundup-Ready soybean seed must take a restricted license to Monsanto’s patents, and must pay a price that includes pass-through of Monsanto’s royalty.³³

The Technology Agreement purports to impose several restrictions on farmers who purchase Roundup-Ready seed. First, farmers must agree to use the purchased seed to grow a commercial crop in a single season only. Second, they must agree not to provide the purchased seed to anyone else for planting. Third, they must agree not to use the seed for breeding, research, or similar purposes, nor to allow anyone else to do so. And finally (and most importantly for present purposes), they must agree not to save any of the crop grown from the purchased seeds to be replanted, either by the farmer-licensee or by anyone else.³⁴

In *Monsanto Co. v. McFarling*, the defendant farmer acceded to the Technology Agreement and then intentionally violated its terms by saving and replanting crops grown from the licensed seed for two successive seasons.³⁵ Monsanto sued him for patent infringement and breach of contract, and prevailed in district court, first obtaining a preliminary injunction³⁶ and ultimately winning summary judgment on the central questions of liability.³⁷ In both instances Monsanto overcame McFarling’s assertion of patent misuse and first sale defenses. In finding for Monsanto, the Federal Circuit did obliquely refer to its “conditional sale” exception to the first sale doctrine,³⁸ but did not resolve the first sale defense on that basis. Rather, it reasoned that “[t]he original sale of the [first-generation] seeds did not confer a license to construct new seeds, and since the new seeds were not sold by the patentee they entailed no principle of patent exhaustion.”³⁹ The Federal Circuit thus drew on the Supreme Court’s distinction, noted above,⁴⁰ between *using* a patented article and *making* a new article.

In *Monsanto Co. v. Scruggs*, the farmer claimed to have acquired Roundup-Ready seed from one of Monsanto’s licensed seed manufacturers in

33. *McFarling II*, 363 F.3d at 1339; *Monsanto Co. v. Bowman*, 657 F.3d 1341, 1344-45 (Fed. Cir. 2011), *cert. granted*, 133 S. Ct. 420 (U.S. Oct. 5, 2012) (No. 11-796); *Scruggs*, 459 F.3d at 1333.

34. *Id.*

35. *McFarling II*, 363 F.3d at 1339.

36. *See Monsanto Co. v. McFarling (McFarling I)*, 302 F.3d 1291, 1296-99 (Fed. Cir. 2002) (affirming preliminary injunction).

37. *Monsanto Co. v. McFarling*, 2002 WL 32069634, at *3-5 (Nov. 5, 2002).

38. *McFarling I*, 302 F.3d at 1299 (quoting *B. Braun Medical, Inc. v. Abbott Labs.*, 124 F.3d 1419, 1426 (Fed. Cir. 1997), a conditional sale case).

39. *Id.*

40. *Aro Mfg. Co., Inc. v. Convertible Top Replacement Co.*, 365 U.S. 336, 342-46 & n.9 (1961); *cf. Am. Cotton-Tie Co. v. Simmons*, 106 U.S. 89 (1882) (finding refurbishment of used and severed patented cotton bale ties marked with a “use once only” restriction to be an infringement, without discussing the first sale issue).

an unrestricted sale—*i.e.*, without agreeing to Monsanto’s Technology Agreement, in violation of Monsanto’s license to the seed manufacturer itself.⁴¹ The Federal Circuit again rejected an asserted first sale defense, on two grounds. The first was identical to the holding in *McFarling*: that the second-generation seeds had been *made* by Scruggs rather than sold to him.⁴² The second relied on the conditional license exception to patent exhaustion: Scruggs had never in fact purchased Monsanto’s patented goods in an “authorized” sale, since Monsanto did not authorize its licensed seed manufacturers to make unrestricted sales of seeds containing its patented technology and Scruggs was on notice of that restriction.⁴³ Having invoked both the use/make distinction and the Supreme Court’s conditional license rule, the Federal Circuit went on to announce a sweeping new principle: “Applying the first sale doctrine to subsequent generations of self-replicating technology would eviscerate the rights of the patent holder.”⁴⁴

In *Monsanto Co. v. Bowman*, an Indiana farmer seemed to have found a clever way around Monsanto’s license terms. Rather than saving seed from his first-generation crop, he sold that crop into the commodity market, then later went to a “grain elevator”—a wholesaler in the commodity grain and oilseed market—and purchased commodity soybeans to be used as seed for a second crop.⁴⁵ Because approximately 94% of Indiana’s soybean acreage is planted with herbicide-resistant seed, many of these commodity soybeans expressed the Roundup-Ready trait, meaning Bowman was able to clean and plant the purchased commodity soybeans and treat them with glyphosate.⁴⁶ Bowman then saved the seed grown from that second crop for replanting.⁴⁷ Because Monsanto’s Technology Agreement expressly permits farmers to sell second-generation soybeans to grain elevators as a commodity, Bowman argued that Monsanto’s patents were exhausted as to the commodity seeds he purchased from the local grain elevator, leaving him free to use them as he saw fit.⁴⁸

As ingenious as Bowman’s workaround of the Monsanto Technology Agreement may seem, it did not amuse the Federal Circuit. That court once again invoked the use/make distinction, holding that even if Monsanto’s rights in the commodity seeds were exhausted, once Bowman planted those seeds and raised the resulting plants he had *made* an unauthorized newly infringing article as to which Monsanto retained its patent rights.⁴⁹ Again, the court held,

41. *Monsanto Co. v. Scruggs*, 459 F.3d 1328, 1333 (Fed. Cir. 2006).

42. *Id.* at 1336.

43. *Id.*; *cf.* *Gen. Talking Pictures Corp. v. W. Elec. Co.*, 304 U.S. 175, 181-82 (1938), *aff’d on reh’g*, 305 U.S. 124 (1938).

44. *Scruggs*, 459 F.3d at 1336.

45. *Monsanto Co. v. Bowman*, 657 F.3d 1341, 1345-46 (Fed. Cir. 2011), *cert. granted*, 133 S. Ct. 420 (U.S. Oct. 5, 2012) (No. 11-796).

46. *Id.*

47. *Id.*

48. *Id.* at 1346.

49. *Id.* at 1348.

applying first sale doctrine to self-replicating technologies would “eviscerate” the patents for such technologies.⁵⁰

B. *Tensions With (and Within) Supreme Court Precedent*

In the Roundup-Ready cases, and particularly in *Bowman*, the Federal Circuit relied heavily on the use/make distinction to find end users of Monsanto’s self-replicating technology to be bound by the restrictions in their license agreements not only as a matter of contract law but as a matter of patent law. Indeed, this would seem to be the only way Bowman’s activities could result in legal liability, as he complied with the express terms of his Technology Agreement. But of course, the application of the use/make distinction in the Roundup-Ready cases ignores the elephant in the room: the only and intended “use” of seeds or any other self-replicating technology necessarily “makes” a newly infringing article—this is the defining characteristic of self-replicating technologies. Indeed, Monsanto’s Technology Agreement explicitly permits end-user farmers to plant, grow (i.e., *make*), harvest, and sell articles reading on Monsanto’s patents. What that agreement purports to restrict is the farmer-licensees’ commercial *uses* of those patented articles, the *making* of which is explicitly authorized. Thus self-replicating technologies, by their nature, destabilize the use/make distinction and render it an inadequate tool for defining the scope and limits of patent rights.

For the same reason, the other distinction in patent exhaustion doctrine—between conditional licenses and conditional sales—breaks down when applied to self-replicating technologies. Viewed in one light, Monsanto’s Technology Agreement can be analogized to the field-of-use restrictions in the manufacturer’s license in *General Talking Pictures Corp. v. Western Electric Co.*⁵¹—it places restrictions on the markets into which farmers *in their capacity as soybean manufacturers* can sell the finished products for which Monsanto’s patented technology is an input. But of course, the Technology Agreement can just as easily be analogized to the label license in *Mallinckrodt*⁵²—it places restrictions on how farmers, *in their capacity as end-users of soybean seed*, can *use* the seed they have purchased. There would not seem to be a basis for favoring one of these analogies over the other as a matter of doctrine; again, farmers who agree to Monsanto’s Technology agreement are, at one and the same time, purchasers of patented articles (the seeds) and licensees in the manufacture of patented articles (plants grown from those seeds). This presents a problem: as end users, Supreme Court precedent might well immunize seed-saving farmers from patent liability—though perhaps not contract liability⁵³—

50. *Id.*

51. 304 U.S. 175, 181-82 (1938), *aff’d on reh’g*, 305 U.S. 124 (1938).

52. *See* *Mallinckrodt, Inc. v. Medipart, Inc.*, 976 F.2d 700, 703-09 (1992); *cf.* sources cited *supra* note 14.

53. *See* *Quanta Computer, Inc. v. LG Electronics, Inc.*, 553 U.S. 617, 637 n.7 (2008)

while recent Federal Circuit doctrine would not.⁵⁴ As licensees, however, even Supreme Court doctrine would hold seed-saving farmers liable for infringement for exceeding the limit of their licensed manufacturing rights.⁵⁵ Again, self-replicating technologies collapse the distinctions at the heart of current patent exhaustion doctrine. The user of such technologies is by definition also a maker of them; his purchase of a patented article is necessarily a license to manufacture more.

The Supreme Court's most recent pronouncements on patent exhaustion, in *Quanta* (and its predecessor, *United States v. Unis Lens Co.*⁵⁶), do not appear to offer a way out of this dilemma. As noted above, at least some judges and scholars believe *Quanta* abrogated the Federal Circuit's conditional sale doctrine.⁵⁷ But there has been no suggestion that *Quanta* abrogates the older line of Supreme Court cases holding that a conditional *license* can operate to render a sale "unauthorized" and thus outside the scope of the first sale doctrine. And it is precisely the distinction between a "sale" and a "license" that self-replicating technologies confound. So even if we ignore the Federal Circuit's conditional sale doctrine, we are still left with the question: are the farmers properly understood as purchasers (such that patent exhaustion applies) or licensed manufacturers (such that it doesn't)?

Perhaps other aspects of the Court's opinions in *Quanta* and *Univis Lens* can offer some guidance on this question. Note that in each of those cases, the patentee authorized the sale of articles that were not literal embodiments of the patented inventions at issue, and yet those sales were held to trigger exhaustion.⁵⁸ In *Univis Lens*, the Court reasoned that the sale of lens blanks "capable of use only in practicing" a patent for finished lenses triggered exhaustion.⁵⁹ In *Quanta*, it reasoned that a semiconductor chipset "substantially embodies" a method patent for a computer system consisting of the chipset plus standard parts and common processes,⁶⁰ and therefore triggers exhaustion upon its sale. Similarly, a seed could well be understood to "substantially embody" the plant that will grow from it, insofar as it requires only standard agricultural processes to produce that very plant. Moreover, a seed for such a plant is

(noting the possible availability of contract remedies even where patent exhaustion applies). Of course other laws, such as antitrust law, might be invoked to hold the post-sale restrictions in Monsanto's technology agreement unenforceable. Cf. Hovenkamp, *supra* note 17, at 541 (discussing the divergence—or lack thereof—between first sale doctrine and antitrust scrutiny of contractual restrictions).

54. See *Gen. Talking Pictures Corp.*, 304 U.S. at 181-82; *Mallinckrodt*, 976 F.2d at 703-09; cf. sources cited *supra* note 14.

55. *Id.*

56. 316 U.S. 241 (1942).

57. See *Quanta*, 533 U.S. at 617, 635-38; see also Hovenkamp, *supra* note 17, at 501 & nn.60, 64; *Static Control Components, Inc. v. Lexmark Int'l, Inc.*, 615 F. Supp. 2d 575, 585-86 (E.D. Ky. 2009).

58. *Univis*, 316 U.S. at 248-50; *Quanta*, 533 U.S. at 630-35.

59. *Univis*, 316 U.S. at 249.

60. *Quanta*, 533 U.S. at 633.

capable of use (as a seed) only in doing precisely that. If the Supreme Court's language is read sufficiently broadly, it could be understood to require the conclusion that the sale of a seed exhausts a patent on the plant grown from that seed, just as the sale of a chipset exhausts a patent for a computer system incorporating the chipset or the sale of a lens blank exhausts a patent for a finished lens made from that blank.

But something about the nature of self-replicating technologies seems to generate an intuitive resistance to this doctrinal analysis. That resistance, I think, rests on an important distinguishing feature of self-replicating technologies that is absent from the technologies at issue in *Quanta* and *Univis Lens*: the ability to generate *multiple embodiments* of the patented invention. Each chipset in *Quanta* could be used to make at most one computer system at any given time; the same could be said of the lens blanks in *Univis Lens*. But a single seed has the potential over time to generate a virtually unlimited number of additional seeds. This basic feature of self-replicating technologies, which the Federal Circuit warned could "eviscerate" patents on them, doesn't really help us resolve the use/make dilemma or the license/sale dilemma. But it does suggest reasons for treating self-replicating technologies differently from other technologies with respect to patent exhaustion. While those reasons are not reflected in the distinctions drawn in extant doctrine, the discussion in the next two Parts will attempt to flesh them out.

III. A FUNCTIONAL APPROACH TO SELF-REPLICATING TECHNOLOGIES

The Federal Circuit held in the Roundup-Ready cases that a second-generation soybean is a different "article" than the first generation seed from which it grew, asserting that any alternative result would "eviscerate" Monsanto's patent. But this is a question-begging response to an unnecessarily formalist question, and there are other, better reasons why it might be undesirable to hold that a patentee's sale of a single embodiment of its self-replicating technology exhausts patent rights with respect to the second, third, or *n*th generation of the technology that is propagated from that first embodiment. Moreover, these other reasons are consistent not only with the rationale for granting patent rights in the first place, but with the pro-competitive principles that justify limiting those rights through exhaustion doctrine.

To get at these reasons, we must look beneath the Federal Circuit's repeated assertion that applying patent exhaustion to subsequent generations of self-replicating technologies would "eviscerate" the patent for such technologies. While rhetorically powerful, the word "eviscerate" does little to illuminate the actual policy implications of the doctrinal choice presented in the Roundup-Ready cases. It does, however, imply a judgment that whatever policies patent protection serves would be undermined by applying patent exhaustion doctrine in this way.

A. *Self-Replication and Self-Disclosure*

Ordinarily we think of patent protection as serving to spur innovation. The promise of supracompetitive returns under a time-limited patent monopoly is thought to provide the incentive to undertake costly investments in innovation that otherwise would not be made (due to the disincentive effects of free-riding by follow-on competitors who do not have to bear the fixed costs of the investments).⁶¹ But beneath this well-worn “incentive to invent” story is a nest of complications. First, many industries seem to be hotbeds of innovation notwithstanding their disqualification from or disuse of patent or any other form of intellectual property protection.⁶² Second, many patentable inventions may go unpatented because their creators do not think the cost of obtaining a patent is justified by the potential returns on the patent monopoly, or because they opt instead for other forms of protection, particularly trade secret protection.

Professor Strandburg has developed a helpful framework for understanding this second group of complications. Strandburg distinguishes between “self-disclosing inventions”—those that “are easily copied from their commercial embodiments”—and “non-self-disclosing” inventions, which are not.⁶³ As she notes, “[t]he free-rider ‘incentive to invent’ theory *does not apply* to non-self-disclosing inventions,” because the creator can commercialize the invention without running the risk of free-riding competitors copying it. For such inventions, the inventor will likely choose between patent protection and trade secret protection based on the relative cost of each approach (determined largely by the costs of prosecuting and defending a patent compared to the costs of maintaining secrecy) and the relative return to each approach (determined largely by the expected life of the patent compared to the expected length of time the secret can be maintained).⁶⁴ For self-disclosing inventions, however, secrecy is not a viable option, and some other means of securing the inventor a return on investment (such as a patent monopoly) will be required to bring the invention to market.⁶⁵

61. See Mark A. Lemley, *The Economics of Improvement in Intellectual Property Law*, 75 TEX. L. REV. 989, 993-1000 (1997); Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, in THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 614-16 (1962).

62. See generally KAL RAUSTIALA & CHRISTOPHER SPRIGMAN, THE KNOCKOFF ECONOMY (2012) (exploring the positive relationship between imitation and innovation in several industries that either cannot or do not access intellectual property protections).

63. Katherine J. Strandburg, *What Does the Public Get? Experimental Use and the Patent Bargain*, 2004 WIS. L. REV. 81, 83.

64. See *id.* at 110. Strandburg’s original framework does not account for the relative cost of obtaining a patent or maintaining secrecy, but others have noted that this comparison is highly relevant to inventors—particularly startups and other small firms—considering which form of legal protection to pursue. See, e.g., Mark A. Lemley, *The Surprising Virtues of Treating Trade Secrets as IP Rights*, 61 STAN. L. REV. 311, 331 (2008).

65. Strandburg, *supra* note 63, at 109 (“For such self-disclosing inventions . . . the primary function of the patent system is to increase the period of market exclusivity enough

The distinction between self-disclosing and non-self-disclosing inventions offers a compelling policy argument in favor of the Federal Circuit's decisions in the Roundup-Ready cases, and a useful tool for the analysis of self-replicating technologies generally. Put simply: *self-replication is an extreme form of self-disclosure*. Self-replicating technologies don't merely teach competitors how to practice a new invention, they supply such competitors with a factory as well. So for novel technologies that we believe have characteristics of public goods and therefore warrant a proprietary right to the inventor in the first place,⁶⁶ self-replication poses an additional barrier to such appropriation. Granting an inventor a property right only in the first generation of a self-replicating technology merely pushes the free-rider problem that patent protection purportedly solves down to subsequent generations.

To see how this free-rider problem might play out, consider what incentives would be generated if the Federal Circuit had come out the other way in the Roundup-Ready cases—i.e., if patent exhaustion applied to the n th generation of a self-replicating technology not only for $n = 1$, but for $n \geq 1$. We can refer to this as the “Exhaustion Scenario.” How would we expect a patentee to respond to such a legal regime? And what do we think would be the implications of that response both for innovation and for competition?

We can begin to answer this question by noting the origins of exhaustion doctrine in what Professor Hovenkamp calls “the leverage theory,”⁶⁷ the idea that in the absence of a first sale defense, patentees might use the leverage of the patent monopoly to extract a “double royalty” from downstream market actors.⁶⁸ In the context of tying doctrines in antitrust law, this theory has drawn criticism from Chicago School economists and defense from other economists.⁶⁹ And there are suggestions in the fight over Roundup-Ready technology that Monsanto's licensing scheme amounts to the kind of “double-dipping” royalty collection that leverage theory adherents abhor in the tying context.⁷⁰ So perhaps the only effect of the Exhaustion Scenario will be that

to provide a sufficient patent return to give an incentive to *invent*.”).

66. See sources cited *supra* note 61.

67. Hovenkamp, *supra* note 17, at 511-14.

68. *Bloomer v. Millinger*, 68 U.S. 340, 350 (1863) (“Patentees . . . are entitled to but one royalty for a patented machine.”). Leverage theory continues to linger beneath the surface of exhaustion doctrine to this day; as Professor Hovenkamp notes, it was an element of the ultimately vindicated district court judgment in the *Quanta* case. Hovenkamp, *supra* note 17, at 512 & n.110, *citing* *LG Electronics, Inc. v. Asustek Computer, Inc.* 2002 WL 31996860, at *4 (N.D. Cal. Aug. 20, 2002) (“The doctrine is designed to prevent a patentee from receiving a double royalty on a single patented invention.”).

69. Compare Ward S. Bowman, Jr., *Tying Arrangements and the Leverage Problem*, 67 *YALE L.J.* 19 (1957) (arguing that only a single monopoly profit can be earned even when bundling a product for which the seller has market power with a product for which it does not), with Einer Elhauge, *Tying, Bundled Discounts, and the Death of the Single Monopoly Profit Theory*, 123 *HARV. L. REV.* 397 (2009) (arguing that the single monopoly profit theory only obtains under limited conditions that are not typical of all tying arrangements).

70. *McFarling II*, 363 F.3d at 1341 (“In McFarling's words, ‘[b]y prohibiting seed-saving, Monsanto has extended its patent on the gene technology to include an unpatented

inventors of self-replicating technologies will be limited (properly!) to a single royalty stream.

The problem with this analysis is that the legal regime of the Exhaustion Scenario operates to foreclose the extraction of monopoly rents not only from downstream secondary market actors and separate markets, but also from later-period players (including repeat players) in the primary market for the patented good itself. In the market for agricultural seeds, for example, the ability of seed purchasers to quickly manufacture competing seeds would make it difficult if not impossible for the inventor of a new seed technology to maintain a price above marginal cost for more than the time it takes to propagate one or two new generations. Generalizing, we could conclude that where certain conditions obtain—such as a significant share of demand coming from repeat or later-period purchasers, a relatively brief generational period compared to the patent term, and a cost of creating the technology that is greater than the premium that could reasonably be captured in a single generation's first-period sales—we would expect the Exhaustion Scenario to dissipate inventors' incentives to bring self-replicating technologies to market. In the Roundup-Ready cases, for example, Monsanto might only be able recoup its investments in Roundup-Ready technology by selling its first generation of seeds to individual farmers for thousands (millions?) of dollars per bag, and at that price the market would be unlikely to clear (especially considering that any purchaser would face the same threat of follow-on competition). This is in essence the same dilemma Strandburg identifies for self-disclosing technologies.⁷¹ So one possible outcome of the Exhaustion Scenario is *diminished innovation*: a decrease in investments in new technologies, and a corresponding decrease in their production.⁷²

But there are alternatives to bringing a technology to market other than declining to invest in the technology's development in the first place. An inventor might try to avoid the free-rider problem, not by declining to *create* a self-replicating technology, but by declining to *sell* it. Thus, a second possible outcome in the Exhaustion Scenario might resemble a trade secrecy regime combined with a program of vertical integration, particularly for technologies that can serve as a factor of production for other goods or services. In the Roundup-Ready example, Monsanto might decide that rather than selling soybean seeds, it should grow its own soybeans and then process them into the various downstream products for which soybeans are an input. This turns out to be a startling array of products, ranging from edible goods like vegetable oil and soy sauce, to agricultural supplies like livestock feed, to industrial products

product—the germplasm—or God-made soybean seed which is not within the terms of the patent.””).

71. Strandburg, *supra* note 63, at 109.

72. This conclusion is typical of earlier treatments of the subject of this Article. See, e.g., Jason Savich, *Note: Monsanto v. Scruggs: The Negative Impact of Patent Exhaustion on Self-Replicating Technology*, 22 BERKELEY TECH. L.J. 115, 127-29 (2007).

like adhesives, textiles, plastics and biofuels.⁷³ And importantly, some of these products will disclose the genetic technology at the core of Monsanto's patents to competitors and some will not, depending on the processing involved at various stages of the production chain. In the Exhaustion Scenario, we might therefore expect Monsanto to decline to allow its technology to be used to make end products that would disclose that technology, and to make other non-disclosing products for which its technology is an input in-house under conditions of secrecy. We can find this state of affairs disagreeable on both innovation and competition policy grounds.

With respect to innovation policy, the Exhaustion Scenario may result in *diminished dissemination of technology* compared to what we would expect under the legal regime developed by the Federal Circuit in the Roundup-Ready cases. This conclusion can be thought of in terms of the "make-or-buy" question typical of economic analysis of firm boundaries. As Professor Coase explains, we can think of the degree of vertical integration of a firm as a function of the comparative transaction costs involved in using the price mechanism as opposed to the hierarchical organization of the firm to direct factors of production.⁷⁴ In the Exhaustion Scenario, however, the relevant question is not "make-or-buy," but rather "make-or-sell." The primary transaction cost at issue in this case, if we can call it that, is the risk of catastrophic free-riding. That cost may be greater or less depending on the extent to which the technology at issue is disclosed by the product being sold.⁷⁵ In general, we would expect the creator of a self-replicating technology to withhold it from the production chains for products that would disclose the technology to end users, while vertically integrating production chains for products that pose no danger of such disclosure.⁷⁶ So returning to the Roundup-Ready example, Monsanto might be willing to make and sell highly refined industrial products derived from soy, but not edible products in which genetic material might still be present, with the result that the latter markets would not benefit from access to Monsanto's technology. Contrast this with the Federal

73. Amer. Soybean Ass'n, SOYBEANS' MANY EDIBLE USES, <http://www.soystats.com/2011/edibleuses.htm> (last visited Feb. 16, 2013); Amer. Soybean Ass'n, SOYBEANS' MANY INDUSTRIAL USES, <http://www.soystats.com/2011/industrialuses.htm> (last visited Feb. 16, 2013).

74. See generally R.H. Coase, *The Nature of the Firm (1937)*, in *THE NATURE OF THE FIRM: ORIGINS, EVOLUTION, AND DEVELOPMENT* (Oliver E. Williamson & Sidney G. Winter eds. 1991).

75. Cf. Julia Porter Liebeskind, *Knowledge, Strategy, and the Theory of the Firm*, 17 STRATEGIC MGMT. J. 93 (1996) (documenting advantages integrated firms enjoy over distributed markets in the protection of information from expropriation).

76. Cf. Edmund W. Kitch, *The Law and Economics of Rights in Information*, 9 J. LEG. STUD. 683, 715-18 (1980) (arguing that firms will vertically integrate to profit from valuable confidential information), citing Benjamin Klein et al., *Vertical Integration, Appropriable Rents, and the Competitive Contracting Process*, 21 J. L. & ECON. 297 (1978) (arguing that vertical integration offers a way for asset-owning firms to minimize the risk of opportunistic appropriation of rents by contracting counterparties).

Circuit's regime, under which Monsanto may license its technology widely to soybean producers and allow those soybeans to be sold as a commodity for any downstream use without fear of free-riders competing away the rents flowing to its patent on the underlying genetic technology. This contrast demonstrates the extent to which the Exhaustion Scenario could curtail dissemination of a useful technology to areas of commerce that might benefit from it.

Similarly, with respect to competition policy, the Exhaustion Scenario could *encourage monopolization of downstream markets* that might otherwise remain competitive, leading to higher prices and lower output than would be the case under the Federal Circuit's approach. This is because the vertical integration strategy described above gives inventors of cost-saving self-replicating technologies the opportunity to use those technologies to charge prices above the inventor's marginal cost but below its rivals' marginal cost in downstream markets, even if other firms would otherwise have competitive advantages in those markets. Thus, the Exhaustion Scenario could lead to a competitive landscape that may generate higher surplus for the inventor, but only at the cost of foregoing greater increases in consumer surplus under the Federal Circuit's regime. Taking the Roundup-Ready cases again as an example, I argued above that in the Exhaustion Scenario Monsanto would have a strong incentive to vertically integrate into non-disclosing downstream markets while withholding its technology entirely from disclosing markets. In particular, it would likely bring in-house the production of end products that would not disclose its genetic technology—soy-fed livestock, or soy-based textiles, or industrial adhesives, for example—because otherwise it would have no way of profiting from the use of its technology as an input into those markets without running the risk of free-riding. Under the Federal Circuit's approach, in contrast, Monsanto's ability to protect itself against free-riders through patent law allows multiple producers in both disclosing *and* non-disclosing downstream markets access to Roundup-Ready soybeans as an input. This allows for competition among such downstream producers with respect to competitive advantages *other than* access to Roundup-Ready soybeans, which we would expect to reduce prices and increase output in those downstream markets even further than the availability of Roundup-Ready technology alone.

In sum, the trade secrecy regime implied by the Exhaustion Scenario is objectionable both on innovation and competition policy grounds. Perhaps for these reasons, the arguments of those who disagree with the Federal Circuit's approach in the Roundup-Ready cases generally do not rest on such a trade secret approach. Instead, advocates propose that contract remedies—which are at least arguably not affected by patent exhaustion⁷⁷—are sufficient to protect the interests of a patentee of self-replicating technologies. For example, Ms. Yee Wah Chin, one of the attorneys representing the interests of Monsanto's farmer customers, argues that “Monsanto could have licensed seedmakers to sell seed embodying Monsanto technology on condition that the second-

77. See *Quanta Computer, Inc. v. LG Electronics, Inc.*, 553 U.S. 617 (2008).

generation seed be either consumed or sold to buyers who agree to either consume the seed or isolate that seed from other seed and sell the seed only for consumption.”⁷⁸ More generally, patentees of self-replicating technologies might require all purchasers of embodiments of those technologies to agree to pay additional royalties on subsequent generations and/or to require their own customers either to take a similar license or to agree not to generate additional embodiments.

There are several problems with this approach. First, it offers only contract remedies in the event of a breach, which differ meaningfully from patent remedies (particularly with respect to the availability of injunctive relief). Second and more importantly, the transaction costs generated by a contract approach are likely to be significantly higher than the approach adopted by the Federal Circuit in the Roundup-Ready cases. In a contract regime, every downstream player in every market for which soybeans are an input would have to take a license from Monsanto, generating additional transaction costs (especially bargaining, monitoring, and enforcement costs) at each layer of the market ecosystem. Moreover, at least some monitoring and enforcement costs would likely be shifted under a contract regime from the patentee to its licensees, who are likely to face significantly higher costs than the patentee (given the patentee’s expertise with its technology) and to introduce agency costs⁷⁹ into the mix (given the relatively weak incentive of Monsanto’s licensees to prevent free-riding). Finally, in the event the technology somehow escapes this web of contracts, it is unlikely that Monsanto could be made whole. This is because it would have rights only against those parties with whom it is in privity of contract. Once the technology escapes the chain of privity, its ability to continually produce increasing numbers of embodiments in which Monsanto’s patent rights are exhausted would render those patents largely useless. Moreover, even if such an escape were the provable result of a licensee’s breach,⁸⁰ a single licensee would be unlikely to have the resources to compensate Monsanto for such a catastrophic loss.⁸¹ Indeed, this risk alone (and a patentee’s recognition of it) is likely to cause the contract regime to collapse into the secrecy regime described above, with all its inherent

78. Yee Wah Chin, *Inexhaustible: Patents on Self-Replicating Technologies*, 3 LANDSLIDE (May/June 2011), available at <http://ssrn.com/abstract=1609794>, at 5.

79. For an overview of the theory of agency costs, see generally Kathleen M. Eisenhardt, *Agency Theory: An Assessment and Review*, 14 ACAD. OF MGMT. REV. 57 (1989).

80. It is entirely plausible that such an escape could occur without any breach of contractual obligations. See generally, e.g., Hilary Preston, Note, *Drift of Patented Genetically Engineered Crops: Rethinking Liability Theories*, 81 TEX. L. REV. 1153 (2003) (discussing the challenge to patent doctrine of the problem of “drift” of genetic material from genetically modified crops to neighboring farms); Paul J. Heald & James Charles Smith, *The Problem of Social Cost in a Genetically Modified Age*, 58 HASTINGS L.J. 87 (2006) (undertaking an economic and legal analysis of the drift problem).

81. Of course, there need not be a breach of license for a self-replicating technology to escape the chain of privity.

drawbacks.

In sum, even though the Federal Circuit's approach in the Roundup-Ready cases seems to limit the scope of the patent exhaustion doctrine as applied to self-replicating technologies, and even though that doctrine is supposedly designed to foster competition and the dissemination of innovative technologies, the analysis above suggests that the alternative—what I have labeled the Exhaustion Scenario—actually fares worse in policy terms. In particular, the Exhaustion Scenario seems likely to generate higher transaction costs, decreased investments in innovation, decreased dissemination of innovation, and reduced competition in downstream markets. This may seem to be a counterintuitive result, and accordingly we can and should question some of the assumptions underlying the foregoing analysis.

B. *Qualifications and Objections*

One potential—and fundamental—objection to the foregoing analysis is that the patent incentive is unnecessary to secure production of self-replicating technologies, and thus the scope of patent rights in such technologies should be limited wherever possible.⁸² This is a species of the general critique of the “incentive to invent” thesis in intellectual property law.⁸³ The types of self-replicating technologies at issue in the Roundup-Ready cases are fairly new to the patent system, but they are not at all new to commerce. Unrestricted transfers, seed-saving, and follow-on improvements were the engine of innovation in new agricultural varieties for centuries, and no patent monopoly was needed to ensure a plentiful and steadily increasing variety of novel and improved agricultural products.⁸⁴ Early interventions of the patent system into

82. This argument, which sees a restrictive patent exhaustion doctrine as a kind of balancing mechanism against overbroad patent rights in the patent system at large, is similar to one made by Professor Merges in support of allowing patent misuse policy to be more muscular than antitrust tying policy so as to balance out other potentially anticompetitive advantages conferred on patentees. *See generally* Robert P. Merges, *Reflections on Current Legislation Affecting Patent Misuse*, 70 J. PAT. & TRADEMARK OFF. SOC'Y 793, 797 (1988) (“[P]roponents of a unified antitrust analysis overlook the fact that patent misuse serves as a valuable counterweight to equitable doctrines that favor the patentee.”).

83. *See generally* Eric E. Johnson, *Intellectual Property and the Incentive Fallacy*, 39 FLA. ST. U. L. REV. 623 (2012) (claiming that external or pecuniary incentives are in general not needed to secure socially valuable innovations); *see also supra* note 62 and accompanying text. *Cf.* Mark A. Lemley, *Property, Intellectual Property, and Free Riding*, 83 TEX. L. REV. 1031 (2005) (arguing that whatever incentives may be needed to spur innovation they do not entail the complete capture of social benefits by the innovator).

84. *See generally* NOEL KINGSBURY, *HYBRID: THE HISTORY AND SCIENCE OF PLANT BREEDING* (2011). Kingsbury's account suggests that the flourishing of new varieties and commercial-scale seed companies in the period from the late eighteenth century to the early twentieth century depended not on the availability of patent monopolies, but on the returns to a reputation for consistent production of high-quality innovations—more a trademark story than a patent story. *See id.* at 83-141. Of course, the poor understanding of genetics during that period combined with the difficulty of propagating desirable traits without such an understanding meant that many new varieties were not strictly self-replicating in the sense

the market for plant varieties also limited appropriability without any apparent cost to innovation. Breeders' rights under the Plant Patent Act of 1930 (PPA)⁸⁵ were limited to asexual reproduction (e.g., propagation by grafts and cuttings from the original patented plant itself),⁸⁶ while the Plant Variety Protection Act of 1970⁸⁷ explicitly included a seed-saving right that is essentially equivalent to the position advocated by McFarling in his battle with Monsanto.⁸⁸ In the interim between those regimes and the utility patent regime consolidated by *J.E.M. Ag Supply, Inc. v. Pioneer Hi-Bred International*,⁸⁹ the "Green Revolution" that transformed world agriculture with huge gains in productivity through innovative breeding programs was accomplished largely on the strength of publicly and philanthropically funded institutions and researchers, not patent grants.⁹⁰ In short, the historical evidence in favor of the "incentive to invent" theory for self-replicating technologies is not especially strong.⁹¹

Assuming that we, nevertheless, remain committed to the patent system as a component of our innovation policy, it is still not at all clear that all

under consideration here. *See id.*

85. Plant Protection Act, Pub. L. No. 71-245, ch. 312, 46 Stat. 376 (1930).

86. *Id.* (excluding sexually reproduced plants and tubers from plant patent protection); *see also* *Imazio Nursery, Inc. v. Dania Greenhouses*, 69 F.3d 1560, 1570 (Fed. Cir. 1995) (holding that infringement under the successor to the PPA requires reproduction by grafting, cutting, and other physical divisions of the original patented plant, rather than by seed or by independent cultivation).

87. Plant Variety Protection Act ("PVPA"), Pub. L. No. 91-577, 84 Stat. 1542 (1970).

88. Compare PVPA § 113, 84 Stat. at 1555, codified as amended at 7 U.S.C. § 2543 (granting farmers a right to save seeds produced by patented plants), with *McFarling I*, 302 F.3d at 1299 (arguing for extension of the PVPA's seed-saving right to Monsanto's genetically engineered seeds).

89. 534 U.S. 124, 127 (2001) (holding that neither the Plant Patent Act nor the Plant Variety Protection Act forecloses utility patent protection for plant varieties under the Patent Act, which does not include the farmer's seed-saving privilege).

90. *See generally, e.g.*, Peter B.R. Hazell, *Green Revolution*, in THE OXFORD ENCYCLOPEDIA OF ECONOMIC HISTORY (Joel Mokyr ed. 2003). *See also* Andrew Pollack, *The Green Revolution Yields to the Bottom Line*, N.Y. TIMES (May 15, 2001), <http://www.nytimes.com/2001/05/15/science/the-green-revolution-yields-to-the-bottom-line.html> ("The gene that spurred the green revolution in the 1960's—creating high-yield grain and helping alleviate world hunger—was provided to Dr. Norman E. Borlaug by Washington State University. 'If that happened today,' he said, 'Washington State would take out a patent and license it to DuPont or Monsanto or somebody.'").

91. One possible objection to this argument is that the type of genetic engineering technology at stake in the Roundup-Ready cases requires significantly more capital to produce than earlier forms of agricultural innovation, and thus requires the additional incentive of the patent monopoly in order to encourage the requisite capital formation. But this objection founders somewhat upon the immense public and philanthropic investments underlying the Green Revolution (*see supra* note 90), as well as the fact that much of Monsanto's own technology was developed at a public research university. *See Monsanto v. Scroggs*, 342 F. Supp. 2d 584, 587 (N.D. Miss. 2004) (describing contributions to Roundup-Ready technology by a researcher at the University of British Columbia); Univ. of British Columbia, *A Brief History of the University of British Columbia*, U. BRIT. COLUM., http://www.library.ubc.ca/archives/hist_ubc.html (last visited Feb. 16, 2013) (charting the history of the University of British Columbia as a public institution).

industries, nor even all self-replicating technologies, will present the same set of incentives as hypothesized in the foregoing discussion.⁹² I have already suggested that the problem of downstream free-riding on self-replicating technologies might only obtain under certain specified conditions.⁹³ More generally, the structure of demand and the nature of downstream uses of any particular self-replicating technology are likely to influence whether a shift of the free-rider problem into subsequent generations of that technology is likely.

As an example, imagine a replication-capable virus used as a vector to deliver genetic therapies specifically designed to target a particular patient's cancer.⁹⁴ True, the technology's usefulness may hinge on its ability to self-replicate from a relatively small number of initial embodiments.⁹⁵ But the additional embodiments created may not affect follow-on demand from the purchaser of the first embodiment—who, if treatment is successful (and, sadly, even if it is not), is likely to exit the market. Nor would those embodiments be likely to affect demand from other consumers whose cancers and immune systems might be sufficiently different to render another patient's treatment useless or even harmful, even if subsequent-generation embodiments could be successfully, safely, and economically harvested from an earlier purchaser for reuse elsewhere. In short, *n*th-generation embodiments of self-replicating technologies used in medicine—particularly personalized medicine—may not significantly affect demand for first-generation embodiments, because the nature of those technologies may render *n*th-generation embodiments poor substitutes for first-generation embodiments.

Contrast this hypothetical example with markets for commodities like soybeans, and it becomes apparent that not all patents for self-replicating technologies will necessarily be “eviscerated” should a purchaser of one embodiment use it without restriction to generate more. Importantly, this difference does not appear to map to the use/make distinction or the purchase/license distinction. Those distinctions thus appear unlikely to capture economically relevant variations in the structure of demand across current or potential future self-replicating technologies. Accordingly, some other doctrinal

92. Cf. generally DAN L. BURK & MARK A. LEMLEY, *THE PATENT CRISIS AND HOW THE COURTS CAN SOLVE IT* (2009) (advocating recognition of industry-specific differences in the appropriate scope of patent protection and identifying doctrinal policy levers for tailoring protection accordingly).

93. See *supra* note 71 and accompanying text.

94. See generally Mark A. Kay et al., *Viral Vectors for Gene Therapy: The Art of Turning Infectious Agents into Vehicles of Therapeutics*, 7 *NATURE MED.* 33 (2001) (presenting an overview of this developing area of biotechnology); Charlotte Dalba et al., *Replication-Competent Vectors and Empty Virus-Like Particles: New Retroviral Vector Designs for Cancer Gene Therapy or Vaccines*, 15 *MOLECULAR THERAPY* 457 (2007) (discussing the benefits and risks of replication-capable viral vectors).

95. See Dalba et al., *supra* note 94, at 460-61 (noting that replication-defective vectors have failed in cancer gene therapy, but replication-capable vectors show promise for more efficient and thorough transduction to cancer tissues with minimal spread to non-targeted tissues).

tools for capturing these differences are warranted if we want patent exhaustion doctrine to reflect sound innovation and competition policy.

IV. SUBSTITUTION AND THE COPYRIGHT ANALOGY: BALANCING INCENTIVES AND ACCESS

I propose that a more fruitful approach to setting the scope of exhaustion doctrine may be found in the type of economic analysis typical of antitrust law. As Professors Lemley and McKenna have pointed out, something like antitrust market definition is already endemic to intellectual property law,⁹⁶ and is a standard part of lost-profits damages analysis in patent law.⁹⁷ They propose that such analysis may inform exhaustion doctrine as well, insofar as used goods are often the most likely substitutes for new goods covered by an intellectual property right.⁹⁸ I would take their insights a step further, and argue that the concept of substitution—the cross-elasticity of demand at the heart of market definition in antitrust law⁹⁹—is key to understanding the economic implications of exhaustion doctrine for self-replicating technologies, and perhaps for patent law in general.

Specifically, we should recognize that the “evisceration” feared by the Federal Circuit appears to be evisceration of the monopoly power that allows a patentee to charge a supracompetitive price for a *first-generation* embodiment of its technology. It is the fear that, left unchecked, competition from *n*th-generation embodiments sold by purchasers of first-generation embodiments will ultimately supplant demand for first-generation embodiments sold by (or under the authority of) the patentee. It is, in other words, a fear of *substitution*. After all, *n*th-generation embodiments of self-replicating technologies *may well be perfect substitutes* for first-generation embodiments. In terms of market definition analysis in antitrust law, we might conclude that the different generational cohorts of self-replicating technologies exhibit perfect cross-elasticity of demand and that they unquestionably comprise a single undifferentiated market. Thus, the threat inherent in applying exhaustion doctrine to self-replicating technologies is that exhausted *n*th-generation embodiments will swiftly cannibalize the market for first-generation embodiments.

This is a peculiar threat that is not present in other forms of competition that patentees might face. Lemley and McKenna rightly note when discussing exhaustion doctrine that used goods are often the most likely substitutes for

96. Mark A. Lemley & Mark P. McKenna, *Is Pepsi Really a Substitute for Coke? Market Definition in Antitrust and IP*, 100 GEO. L.J. 2055 (2012).

97. *Id.* at 2070-71.

98. *Id.* at 2115-17.

99. As Professor Hovenkamp points out in his response to Lemley and McKenna’s article, concepts like substitution and cross-elasticity of demand may be better understood as (perhaps superior) alternatives to market definition rather than as proxies for it. Herbert Hovenkamp, *Response: Markets in IP and Antitrust*, 100 GEO. L.J. 2133, 2141-42 (2012).

new goods,¹⁰⁰ but they are typically not going to be *perfect* substitutes. For example, they may have suffered wear that makes them less functional, durable, or desirable than new goods; or they may require the outlay of additional costs (over and above the cost of a purchase authorized by the patentee) in order to bring them up to a level of quality sufficient to render them acceptable substitutes for new goods. Similarly, a patent confers a right to exclude others from accessing the precise technological solution to a problem that the patent claims, though it does not affect the right of others to devise *other* technological solutions to the same problem.¹⁰¹ As Professors Fromer and Lemley argue in forthcoming work, patent law's implicit distinction between *technical* and *market* substitutes may spur salutary competition to generate *alternative* (and potentially superior) solutions to the commercial problem addressed by a patent,¹⁰² but again, perfect cross-elasticity of demand between such alternatives is unlikely. While both of these forms of competition—from used goods and from alternative solutions to a common problem—might divert some demand from a patented technology, neither seems to threaten the type of perfect substitution that would unravel the patentee's monopoly in the patented technology itself.

Perhaps this threat can best be thought of by analogy to a different area of intellectual property law: copyright. The danger to which the Federal Circuit seemed to respond in the Roundup-Ready cases is essentially identical to the danger that is thought to justify the reproduction right in copyright law—another legal tool to prevent purchasers of an article from generating multiple identical articles.¹⁰³ Consider Professor Landes's and Judge Posner's canonical economic analysis of the reproduction right:

While the cost of creating a work subject to copyright protection . . . is often high, the cost of reproducing the work . . . is often low. And once copies are available to others, it is often inexpensive for these users to make additional copies. If the copies made by the creator of the work are priced at or close to marginal cost, others may be discouraged from making copies, but the creator's total revenues may not be sufficient to cover the cost of creating the work. Copyright protection—the right of the copyright's owner to prevent others from making copies—trades off the costs of limiting access to a work

100. See Lemley & McKenna, *supra* note 98, at 2115-17.

101. This feature of the patent system has spawned a long history of format wars, from the electric current war between Thomas Edison and George Westinghouse to the battle between Sony and Toshiba over standards for high-definition DVDs. Notably, these contests are fought and decided in the marketplace, not in courts or the Patent Office.

102. Jeanne C. Fromer & Mark A. Lemley, *Audience and Substitution in IP Infringement* (Oct. 10, 2012) (unpublished manuscript), <http://camlaw.rutgers.edu/sites/camlaw/files/fromer.pdf> (“Subsequent inventors can develop a variety of market substitutes that are not also technological substitutes without running afoul of patent law. This market substitution benefits consumers and helps drive the progress of science and technology.”).

103. See 17 U.S.C. § 106 (2012) (“[T]he owner of copyright . . . has the exclusive rights . . . to reproduce the copyrighted work . . .”); William M. Landes and Richard A. Posner, *An Economic Analysis of Copyright Law*, 18 J. LEG. STUD. 325, 326 (1989).

against the benefits of providing incentives to create the work in the first place.¹⁰⁴

Landes and Posner may as well have been speaking here about the application of patent protection to self-replicating technologies.

Of course, copyright law has its own exhaustion defense—and a statutory one at that.¹⁰⁵ But notably, that defense modifies the copyright owner's *distribution* right, but not his *reproduction* right.¹⁰⁶ If we were to apply an analogous principle in the Roundup-Ready cases, we might allow a farmer to resell (i.e., distribute) the seeds he purchases, but not to use them to make additional seeds (i.e., reproductions), at least as a matter of intellectual property law. This conclusion resonates strongly with the use/make distinction in patent law's exhaustion doctrine, but again founders on the inseparability of use and replication. Unlike a copy of a copyrighted work, an embodiment of a self-replicating technology cannot be used by its first purchaser prior to resale without creating a new embodiment. So a mechanical extension of the distribution/reproduction distinction of copyright law to patent exhaustion doctrine ends up giving the purchaser of an embodiment of a self-replicating technology significantly narrower rights than the purchaser of a copy of a copyrighted work. We might therefore eschew formal analogies and take a closer look at the policy justifications for copyright's exhaustion doctrine—and particularly the role in those policies of substitution—to inform our analysis of patent exhaustion as applied to self-replicating technologies and more generally.

One of these justifications in particular is informative. As Professor Reese explains, one argument in favor of copyright's exhaustion doctrine is that it mitigates some of the more unfortunate results of intellectual property law's policy of using monopoly rights to incentivize innovation.¹⁰⁷ In particular, an exhaustion defense to infringement liability allows for at least some expansion of access to a copyrighted work beyond the pool of consumers willing and able to pay the copyright owner's monopoly price, without unduly threatening the copyright owner's ability to charge that monopoly price in the first place.¹⁰⁸ It is, in essence, a policy lever to balance the incentives to innovation that intellectual property rights provide against the access to knowledge that they—at least temporarily—restrict. This view of exhaustion doctrine's role is consistent with the argument raised above that intellectual property rights ought *in principle* to be limited where possible,¹⁰⁹ and with the classic Jeffersonian characterization of intellectual property monopolies as “embarrassment[s]” to

104. Landes & Posner, *supra* note 103, at 326.

105. 17 U.S.C. § 109 (2012).

106. 17 U.S.C. § 109(a) (2012) (qualifying the distribution right of 17 U.S.C. § 106(3), but not the reproduction right of 17 U.S.C. § 106(1)).

107. See R. Anthony Reese, *The First Sale Doctrine in the Era of Digital Networks*, 44 B.C.L. REV. 577, 583-92 (2003).

108. *Id.*

109. See *supra* note 82 and accompanying text.

be grudgingly tolerated rather than fundamental rights to be zealously reinforced.¹¹⁰

This understanding of the role and the stakes of exhaustion doctrine—and particularly the role of substitution in determining its scope—offers far more useful tools for distinguishing among the cases and hypothetical cases discussed in this Article than the various doctrinal distinctions on which they currently rest. For example, take the discussion of *Quanta* and *Univis Lens* above, where it was noted that language of those cases might be read to give the farmers in the Roundup-Ready cases a defense.¹¹¹ The intuition against this result, as I noted, may be rooted in the recognition that a single exhausted embodiment (or substantial embodiment) is somehow meaningfully different from a potentially unlimited number of exhausted *n*th-generation embodiments,¹¹² but we can now go further and explain *why* that distinction ought to be deemed relevant. Put simply, it is because extending the exhaustion doctrine to cover such *n*th-generation embodiments would scotch the balance between incentives and access. True, it would expand access to the patented technology greatly, but only by flooding the market with perfect substitutes that make it impossible for the patentee to maintain a supracompetitive price for first-generation embodiments. It is this inability to charge a supracompetitive price that threatens to negate whatever incentive to innovation patent law affords, and thereby creates the incentive to resort to the alternative unsatisfactory regimes analyzed in Part III.

This same framework of balancing incentives against access can similarly help us to explain the distinction between Roundup-Ready seeds and the engineered viral vector described at the conclusion of Part III.¹¹³ Here, it is not the *number* of *n*th-generation embodiments that matters, but the extent to which *any* *n*th-generation embodiment is a good substitute for a first-generation embodiment. Because the *n*th-generation viruses are likely only useful to the person who purchased the first-generation virus that produced them, and because such a person is unlikely to be able to obtain a suitable *n*th-generation virus without first obtaining a first-generation virus, it is unlikely that holding *n*th-generation viruses exhausted would have any effect on the patentee's ability to charge a supracompetitive price for first-generation viruses, thus obviating the need to resort to legal regimes other than patent law. Conversely, holding such *n*th-generation viruses exhausted would be unlikely to significantly expand access, while failing to so hold might give a patentee

110. THOMAS JEFFERSON, Letter from Thomas Jefferson to Isaac McPherson (Aug. 13, 1813), in 13 THE WRITINGS OF THOMAS JEFFERSON 326, 334–35 (Andrew A. Lipscomb ed., 1903). For a skeptical view of the historical and jurisprudential relevance of Jefferson's oft-cited characterization, see generally Adam Mossoff, *Who Cares What Thomas Jefferson Thought About Patents? Reevaluating the Patent "Privilege" in Historical Context*, 92 CORNELL L. REV. 953 (2007).

111. See *supra* notes 58–60 and accompanying text.

112. *Id.*

113. See *supra* notes 94–95 and accompanying text.

significant power to restrict access in potentially harmful ways.¹¹⁴

The foregoing discussion not only demonstrates the power of the functional analysis developed in this Article in distinguishing among good and bad exhaustion claims, but it illustrates the inability of the formalist analysis in extant precedent to do so. Comparison of *Quanta* and *Univis Lens* on the one hand with the Roundup-Ready cases on the other suggests that the fact that a defendant is “using” an embodiment is not a sufficient condition for the exhaustion defense to apply. Conversely, comparison of the Roundup-Ready cases and the hypothetical viral vector example suggests that the fact a defendant is “making” an embodiment is not sufficient to demonstrate that the exhaustion defense should fail. The latter comparison similarly demonstrates that self-replication need not be in itself a bar to an exhaustion defense. In short, neither the use/make distinction nor the ability of a technology to self-replicate are sufficient factual predicates for determining the applicability of the exhaustion doctrine. In all instances, some recourse to the concept of substitution—and underlying it a meaningful analysis of the nature of the technology at issue and the structure of demand for it—is necessary to draw the relevant distinctions. Ultimately, some judgment about the appropriate balance of access and incentives must be brought to bear as part of that analysis.

We see these principles at work in the Supreme Court’s earlier repair and reconstruction cases: *American Cotton-Tie Co. v. Simmons*¹¹⁵ and *Aro Manufacturing Co. v. Convertible Top Co.*¹¹⁶ In *Simmons*, the disposable nature of the cotton bale ties at issue likely rendered a suitably refurbished tie a very good substitute for a new one, and it seems likely that a single embodiment might profitably be refurbished for reuse more than once.¹¹⁷ This combination of facts might well lead a court to conclude that allowing downstream players to refurbish the patentee’s products could seriously affect the patentee’s ability to charge a supracompetitive price for new embodiments.¹¹⁸ In *Aro Manufacturing*, in contrast, the issue was whether a secondary market seller could supply an unlicensed replacement part for a component of the patentee’s product (the fabric of a convertible car top) that was susceptible to much more rapid wearing out than the rest of the product.¹¹⁹ Allowing such downstream activity might well lengthen the period of repeat

114. For example, if suitable means of measurement are available, the patentee might use replication as a basis to meter its pricing, potentially allowing it to capture more surplus but also potentially pricing out those with the greatest need for the technology. This might be a particularly salient concern for medical technologies.

115. 106 U.S. 89 (1882).

116. 365 U.S. 336 (1961).

117. *Simmons*, 106 U.S. at 91-93 (noting that the defendant purchased severed fragments of used bale-ties in bulk and riveted them back together).

118. *Id.* at 92 (noting that the patentee sold its bale-ties new at 6 cents per pound while the defendant purchased used and severed ties as scrap at 1.25 cents per pound).

119. *Aro Mfg.*, 365 U.S. at 337-38 (“The components of the patented combination, other than the fabric, normally are usable for the lifetime of the car, but the fabric has a much shorter life.”).

demand for new embodiments, but probably not to the extent that the patentee would be unable to charge a supracompetitive price for new embodiments (particularly where its products were mainly purchased by automobile manufacturers for factory installation in new cars).¹²⁰ Of course, these are both issues of degree—in either case the patentee might respond to the alleged infringer’s conduct by raising its price to capture whatever surplus it might lose to secondary market activity, which could reduce demand in the primary market but could also generate complex price discrimination dynamics. The question then becomes one of judgment: whether such a price increase would end up narrowing demand for new embodiments to such an extent as to undermine the incentive to innovate (or, conversely, that insufficient new embodiments would be created to supply the secondary market, undermining the policy of expanding access to technology).

This question of judgment may also help shed light on the distinction that has recently divided the Supreme Court and the Federal Circuit in their patent exhaustion jurisprudence: the distinction between a conditional license and a conditional sale.¹²¹ While a full exploration of that distinction is beyond the scope of this brief Article, it seems to raise the same questions as have been discussed here. Again, these questions address the substitutability of a used secondary market good for a primary market good, the effects of such substitution on the ability of a patentee to charge supracompetitive prices in the primary market, and the balance between the incentives that those supracompetitive prices provide and the access to technology that they curtail. Attempting to characterize a particular transaction as either a license or a sale is not likely to be especially helpful in ascertaining these types of market dynamics. It would probably be more useful to consider the effect of enforcing the post-transaction restrictions the patentee seeks to impose on access to the patentee’s technology, and conversely the effect of refusing to enforce those restrictions on its ability to charge a supracompetitive price sufficient to recoup its investment by some other means within the patent system. Such questions are likely to be significantly more complex than the analysis in this Article, particularly in light of the broad array of alternative transactional arrangements by which a given technology might be commercialized and the varying degrees of market interventions a court might have to consider in deciding whether a particular transactional arrangement strikes an appropriate balance between incentives and access.¹²² But ultimately, this appears to be the fundamental

120. *Id.* at 337 (“Tops embodying the patent have been installed by several automobile manufacturers in various models of convertibles.”).

121. See sources cited *supra* notes 21-27 and accompanying text.

122. For example, in a case like *Mallinckrodt, Inc. v. Medipart, Inc.*, 976 F.2d 700 (Fed. Cir. 1992), we might be uncomfortable with a court deciding that the patentee ought to charge more for new devices—squeezing some customers out of the primary market—for the purpose of encouraging development of a secondary market. The incentives facing a monopolistic seller in such a circumstance are actually quite complex, even under the simplifying assumption that secondary market goods are not differentiated from primary

question implicated by judicial decisions on the scope of exhaustion doctrine.

CONCLUSION

Given how little we can presume to know about the future development of self-replicating technologies, it is likely unwise to try to set a bright-line rule today to govern the rights of downstream users for all such technologies that may arise tomorrow. Fortunately, the Supreme Court appears to be highly attuned (perhaps to a fault) to this danger.¹²³ What would be welcome as the Supreme Court considers the *Bowman* case is an attention to function over form, and a due regard for the effects of a rule on innovation, competition, and access to technology throughout and across markets, rather than an effort to justify selection of one out of two equally plausible characterizations of a particular transaction. So long as we continually ask ourselves what incentives will be created by holding a patent exhausted in a particular set of circumstances, and how those incentives will affect the scope of competition and innovation going forward, the self-replicating technologies of the future need not throw the doctrine of patent exhaustion into disarray. To the contrary, they may be uniquely suited to clarifying the economic issues at the root of exhaustion doctrine, as this Article has argued. In particular, self-replicating technologies may present unique problems of secondary-market substitution, undermining the ability of a patentee to charge supracompetitive prices in its primary market and thereby leading innovators to seek out non-patent means of appropriating the value of their innovations. But while many self-replicating technologies *can* present such problems, it is by no means certain that *all* self-replicating technologies will do so, and this Article's exploration of what makes self-replication such a threat to a patentee has illuminated the fundamental economic issues implicated by the scope of the exhaustion defense. Rather than attempting to set the boundaries of exhaustion doctrine by reference to unstable formal categories (be they self-replicating/non-self-replicating, use/make, or license/sale), courts would better serve the innovation and competition policies underlying the doctrine by frankly assessing the application of those policies to the nuanced factual settings of individual cases.

market goods. *See generally* Giacomo Calzolari & Alessandro Pavan, *Monopoly with Resale*, 37 RAND J. ECON. 362 (2006) (modeling interactions between monopolist sellers in a primary market and buyers in primary and secondary markets).

123. *See, e.g.*, *Bilski v. Kappos*, 130 S. Ct. 3218, 3227-28 (2010).