Vanderbilt Journal of Entertainment & Technology Law

Volume 18
Issue 2 *Issue 2 - Winter 2016*

Article 4

2016

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ABSTRACT

The challenge of achieving socially optimal incentives for innovation in public goods faces twin market failures: a market failure to adequately promote public goods invention and a market failure to implement innovative public goods once developed. Though innovation in private goods sometimes faces the former hurdle, often ameliorated by intellectual property law, the interaction of both market failures for public goods innovation raises unique difficulties.

Environmentally beneficial technology presents an illustration of the innovation problem for public goods. Private actors lack sufficient incentives both to engage in environmentally beneficial innovation and to implement such innovation. While traditional intellectual property law and environmental law fail to cure the interaction of these public goods market failures, an innovation rewards system could produce more socially appropriate incentives. Using environmentally beneficial innovation as an example, this Article introduces a new framework for an innovation rewards system for public goods and discusses its implementation and potential advantages.

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I. INTRODUCTION

Despite numerous and diverse efforts, one significant goal that has largely eluded environmental law is adequately promoting environmentally beneficial innovation. While there have been many attempts at technology-forcing and innovation-promoting legislation in jurisdictions around the world, success has been limited.[1]

1. *See, e.g.*, ENVTL. LAW INST., BARRIERS TO ENVIRONMENTAL TECHNOLOGY INNOVATION AND USE (1998) (criticizing technology-based emission limits (such as in the CAA and CWA) for discouraging innovation); Jonathan H. Adler, *Eyes on a Climate Prize: Rewarding Energy Innovation to Achieve Climate Stabilization*, 35 HARV. ENVTL. L. REV. 1, 36–40 (2011) (discussing insufficiency of regulation to address global climate change); David M. Driesen, Symposium, *The Economic Dynamics of Environmental Law: Cost-Benefit Analysis, Emissions Trading, and Priority-Setting*, 31 B.C. ENVTL. AFF. L. REV. 501, 514–20 (2004) (examining the economic dynamics of environmental law as a factor for innovation); Adam B. Jaffe et al., *Technological Change and the Environment*, 1 HANDBOOK OF ENVTL. ECON. 461, 476–85 (Karl-Göran Mäler & Jeffrey R. Vincent eds., 2003) (contending that command-and-control regulations do not provide incentives for companies to exceed control targets and to adopt new technologies); Martin Jänicke & Stefan Lindemann, *Governing Environmental Innovations*, 19 ENVTL. POL. 127, 129 (2010) (discussing how environmental law leads to "weak" environmental innovations, which have minimal environmental impact); Joseph Szarka, *Climate Challenges, Ecological Modernization, and Technological Forcing: Policy Lessons from a Comparative US-EU Analysis*, 12 GLOBAL ENVTL. POL. 87, 93–102 (2012) (arguing that technology-forcing environmental law and technological improvements have proved insufficient to address climate challenges); Margaret R. Taylor et al., *Regulation as the Mother of Innovation: The Case of SO_2 Control*, 27 LAW & POL'Y 348, 350 (2005) (discussing the argument that traditional environmental regulation does not provide a continuous incentive for innovation). *But cf.* Jaegul Lee et al., *Forcing Technological Change: A Case of Automobile Emissions Control Technology Development in the US*, 30 TECHNOVATION 249, 249 (2010) (arguing that high government emissions standards for automobiles stimulated technological innovation in that field).

Technological advances in the environmental area, however, could have myriad benefits—such as cutting pollution, reducing consumption, and improving conservation—and could provide these benefits while simultaneously reducing the cost of environmental protection.[2] The potential welfare gains are thus substantial, as both industry and the general public could be made significantly better off. The challenge of environmentally beneficial innovation, however, faces twin market failures: a failure to adequately incentivize environmentally beneficial activities and a failure to adequately promote innovation.

These twin market failures interact in a deleterious manner that exemplifies the challenge of adequately incentivizing private innovation in public goods. This Article analyzes the twin public goods market failure problem and presents an original innovation rewards framework as a potential means to simultaneously ameliorate both market failures. The framework is developed through a case study on environmentally beneficial innovation and is applicable to a wide variety of public goods.

The market failure produced by the negative externalities of pollution and other environmentally detrimental activities is well studied and a standard story in environmental law.[3] Less attention is paid to a reciprocal, but similarly problematic, failure in the market for environmentally beneficial technological innovation. Just as negative externalities cause private actors to engage in *more* environmentally detrimental activity than is socially optimal, positive externalities concerning the social value of environmentally beneficial innovation cause private entities to engage in *less* research and development of environmentally beneficial technology than is socially optimal. Environmentally beneficial technology has public goods qualities and consequently suffers from an inability of the market to produce accurate demand signals.[4]

Layered on top of the incentives deficit created by positive externalities is a second market failure concerning environmentally beneficial technology, produced by the non-rivalrous and non-exclusive nature of innovation. This is the classic story of intellectual property law. This second public goods market failure can occur because innovation in environmentally beneficial technology may not be adequately incentivized or distributed in a free market. Due to the

2. *See* Szarka, *supra* note 1, at 87–89.

3. Ronald Coase, *The Problem of Social Costs*, 3 J.L. & ECON. 1 (1960); Paul Lehmann, *Justifying a Policy Mix for Pollution Control: A Review of the Economic Literature*, 26 J. ECON. SURV. 71 (2010).

4. Taylor, *supra* note 1, at 348.

ability of consumers and competitors to free ride off of the innovation of others in the absence of intellectual property protection and enforcement, private actors will not innovate at the socially optimal level. In the environmentally beneficial innovation context, these twin market failures of environmental and innovation policy interact in a negative manner that causes standard individual solutions to either problem not to be sufficiently successful. As a consequence, too little environmentally beneficial innovation is produced.

The prevailing wisdom has been that these dual market failures require two independent solutions, separately addressing the environmental and intellectual property issues in the environmentally beneficial technology context.[5] The innovation rewards proposal developed here offers a novel way to address both problems simultaneously, producing a more efficient—and likely more successful—result.

The concept of patent rewards has been suggested in other contexts in an effort to ameliorate certain market failures in intellectual property law.[6] Patent rewards systems replace traditional intellectual property rights with government payments for innovation in exchange for making the innovation freely available. Though patent rewards systems solve deadweight loss and other problems of standard intellectual property law, they generally have not received substantial support.[7]

In the context of the twin public goods innovation market failures, however, a modified innovation rewards system could offer unique synergistic social welfare benefits that make it a particularly attractive solution. In the public goods context, these benefits may enable the modified innovation rewards system developed here to garner greater political viability than traditional rewards recommendations. An innovation rewards system has features that also make it particularly well suited to address certain vexing international environmental challenges and other large-scale public goods problems more generally.

This Article begins with a discussion of the market failures in intellectual property and environmental law, examining the public goods problem in innovation and in environmentally beneficial activities in Parts II and III, respectively. Part IV introduces the innovation rewards system as a potential solution to the twin market

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5. *See* Bronwyn H. Hall & Christian Helmers, *The Role of Patent Protection in (Clean/Green) Technology Transfer*, 26 SANTA CLARA COMPUTER & HIGH TECH. L.J. 487, 489 (2010).

6. *See infra* Part IV.A.

7. *See infra* Part IV.D.

failures problem and concludes with an explanation of how such a system could be applied beyond the domestic sphere to international environmental challenges. The innovation rewards framework can produce significantly more accurate social demand signals for innovation in public goods and consequently could produce substantial welfare gains.[8]

II. THE MARKET FAILURE IN INNOVATION

The standard economic story of intellectual property law, and patent law in particular, is that absent patent protection there would be a market failure in innovation.[9] Individuals and firms would invest fewer resources in research, development, and commercialization than is socially optimal, resulting in less innovation than is socially optimal.[10] This would occur because innovation is generally non-excludable and non-rivalrous: once an idea is disclosed, access cannot be controlled, and one individual's use of the idea behind an invention does not reduce another's ability to use it.[11] Absent patent law, an inventor who builds a better mousetrap and makes it publicly known, such as by commercializing the invention, usually cannot prevent competitors and potential customers from copying the invention many times over without paying royalties.[12] Innovation thus has public goods qualities.[13]

In a world without intellectual property rights, once an invention is achieved and disclosed, anyone can free ride on the invention. As a result, market competition would drive the market price of the invented product down to its free competition price, the

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8. This Article expands upon and draws from an article that the Author first introduced in a presentation published as part of a symposium, Gregory N. Mandel, *Promoting Environmental Innovation with Intellectual Property Innovation: A New Basis for Patent Rewards*, 24 TEMP. ENVTL. L. & TECH. J. 52 (2005).

9. *See, e.g.*, Kewanee Oil Co. v. Bicron, 416 U.S. 470, 480–81 (1974) (discussing how the prospect of obtaining a patent monopoly provides an incentive to invest in efforts to create new inventions); RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 54 (8th ed. 2011).

10. *See, e.g.*, Mazer v. Stein, 347 U.S. 201, 219 (1954) ("The economic philosophy behind the clause empowering Congress to grant patents and copyrights is the conviction that encouragement of individual effort by personal gain is the best way to advance public welfare through the talents of authors and inventors in 'Science and useful Arts.'"); ROBERT P. MERGES, PETER S. MENELL & MARK A. LEMLEY, INTELLECTUAL PROPERTY IN THE NEW TECHNOLOGICAL AGE 12–13 (5th ed. 2010) ("The result [of not providing exclusive rights in intellectual property], according to economic theory, would be an underproduction of books and of other works of invention and creation with similar public goods characteristics.").

11. *See* MERGES ET AL., *supra* note 10, at 12; POSNER, *supra* note 9, at 48–59.

12. Innovation that can be commercialized without disclosure presents a different context.

13. *See* POSNER, *supra* note 9, at 48.

cost of production.[14] An inventor would be unable to recover her or his own costs of innovation, such as research and development costs. This circumstance would reduce or eliminate the possibility of a return on investment for the inventive activities. The inventor therefore would be unable to profit from the invention to the full extent of its social value and consequently would not engage in as substantial potentially beneficial innovation activities in the first instance.[15] Too little invention would occur.

Patent law seeks to solve this market failure by bringing the private benefits of invention more in line with their social value. Once an inventor obtains a patent on a mousetrap, the world has to beat a path to his or her door. The potential grant of exclusionary intellectual property rights, and the concomitant potential monopoly pricing power that they enable, provide inventors with incentives to invest time, financial resources, and effort into the research, development, and commercialization of innovation.[16] The pricing power enabled by exclusionary patent rights permits a patent owner to charge a price for invention products that more closely approaches the value that consumers place on the invention, rather than the free-market competitive price of production.[17] Enabling the inventor to charge a price for invention that approaches the private value of the invention, as opposed to the competitive price, creates incentives for inventors based on how much consumers are willing to pay for the invention. Patent law thus promotes innovation by creating private incentives to invent, disclose, and commercialize inventions that more closely reflect the social welfare that an invention produces.[18] Though this incentive theory of patent law is subject to critique on both efficiency and normative grounds,[19] it is the commonly accepted

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14. *See id.* at 54.

15. *See* Christopher A. Cotropia & James Gibson, *The Upside of Intellectual Property's Downside*, 57 UCLA L. REV. 921, 926 (2010) ("If innovators can only recover their marginal cost of production, they will lack the incentive to create the information good in the first place."); Jeanne C. Fromer, *Expressive Incentives in Intellectual Property*, 98 VA. L. REV. 1745, 1751–52 (2012).

16. *See* MERGES ET AL., *supra* note 10, at 13; POSNER, *supra* note 9, at 48–49.

17. *See* POSNER, *supra* note 9, at 48.

18. *See, e.g.*, Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1024–38 (1989) (discussing how patent law provides these incentives).

19. *See, e.g.*, Eisenberg, *supra* note 18, at 1038–44 (surveying and critiquing a variety of economic theories of patent law); Fromer, *supra* note 15, at 1753–56 (discussing moral rights theories of intellectual property law); Justin Hughes, *The Philosophy of Intellectual Property*, 77 GEO. L.J. 287, 296–330 (1988) (surveying alternate intellectual property law policies, such as natural rights and personality bases); Amy Kapczynski & Talha Syed, *The Continuum of Excludability and the Limits of Patents*, 122 YALE L.J. 1900, 1905–07 (2013) (explaining that patent protection asymmetrically only provides incentives for types of invention that can

dominant model of patent law and policy, and is sufficient for the purposes of discussion here.[20]

Even accepting the incentive-to-innovate model described above, however, intellectual property law still does not efficiently incentivize innovation because the award of a patent grant and consequent monopoly pricing results in lower production of, and higher prices for, the innovation good than is socially optimal.[21] Patent owners obtain a monopoly over the patented subject matter for a limited period of time.[22] The patent owner can then raise the commercial price of their invention above the competitive market price in order to garner the greater monopoly profits described above.[23] Such pricing, however, means that certain firms or consumers who value the invention above its cost of production nevertheless will not purchase and therefore not be able to use the invention due to its higher monopoly price.[24] This creates deadweight loss. Not only does this deadweight loss harm consumers, it further reduces social welfare because potential inventors do not receive socially accurate incentives to innovate as they cannot capture the full social value of their innovation, absent the ability to price discriminate perfectly.[25] More critically, the reduction in demand caused by inflated monopoly pricing will reduce production of the innovation products below optimal levels.[26] Reducing the production, and therefore the consumption, of public goods—and of environmentally beneficial innovation in particular—has severe impacts on its social value because the value of such innovation generally comes from widespread dissemination and adoption.

The foregoing analysis presents a rough overview of the market failure commonly associated with much technology and innovation. Public goods innovation, however, adds a second twist because of the positive externalities that derive from the distribution and

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generate private-market value); Benjamin N. Roin, *Intellectual Property versus Prizes: Reframing the Debate*, 81 U. CHI. L. REV. 999, 1029–34 (2014) (discussing various efficiency critiques of patent law).

20. DAN L. BURK & MARK A. LEMLEY, THE PATENT CRISIS AND HOW THE COURTS CAN SOLVE IT 66–67 (2009) ("[T]heories of patent law based in moral right, reward, or distributive justice . . . are hard to take seriously as explanations for the actual scope of patent law.").

21. *See* Hall & Helmers, *supra* note 5, at 490.

22. Patent terms currently last for twenty years from the date of application. *See* 35 U.S.C. § 154(a) (2011).

23. *See* Robert C. Guell & Marvin Fischbaum, *Toward Allocative Efficiency in the Prescription Drug Industry*, 73 MILBANK Q. 213, 216–17 (1995).

24. *See* Michael Abramowicz, *Perfecting Patent Prizes*, 56 VAND. L. REV. 115, 128–29 (2003).

25. MERGES ET AL., *supra* note 10, at 12–13.

26. *See* Hall & Helmers, *supra* note 5, at 490.

implementation of such technology. These impacts can be seen clearly in the market effects concerning environmentally beneficial technology.

III. THE MARKET FAILURE IN ENVIRONMENTALLY BENEFICIAL TECHNOLOGY

Environmentally beneficial innovation, absent patent law, would face the same market failure as other innovation subject matter: individuals and firms would not engage in enough environmentally beneficial innovation because the non-rivalrous and non-exclusive nature of innovation would allow free market competitors to drive down the price of innovation products to the cost of production, thereby reducing the incentive to innovate below its socially optimal level. As discussed above, patent law helps to ameliorate, but not resolve, the public goods market failure in environmentally beneficial innovation from the innovation perspective. However, environmentally beneficial innovation faces a second public goods market failure as well—a market failure that results from the positive environmental externalities produced by environmental innovation. It is this latter market failure that reveals why existing patent law, though potentially providing improved incentives for certain types of innovation, is not sufficient to promote socially optimal levels of innovation in public goods, including environmentally beneficial innovation.

Negative externalities refer to costs imposed on others by a private individual's actions for which the individual does not have to pay.[27] Environmental pollution and other environmental degradation are classic examples of negative externalities.[28] Entities that engage in environmentally injurious activities often do not pay the full health, medical, or environmental costs of their environmental degradation and therefore engage in more environmentally degrading activity than is socially optimal.[29] As a result, a free market produces more environmentally degrading activity than is socially efficient.[30] The problematic effects of the negative externalities of environmentally

27. Brett M. Frischmann & Mark A. Lemley, *Spillovers*, 107 COLUM. L. REV. 257, 262 (2007); David Popp, Richard G. Newell, & Adam B. Jaffe, *Energy, the Environment, and Technological Change* 2 (Nat'l Bureau of Econ. Research, Working Paper No. 14832, 2009), http://www.nber.org/papers/w14832.pdf.

28. *See generally* Richard L. Revesz, *Federalism and Interstate Environmental Externalities*, 144 U. PENN. L. REV. 2341, 2343 (1996).

29. *See* William H. Sandholm, *Negative Externalities and Evolutionary Implementation*, 72 REV. ECON. STUD. 885, 897–903 (2005).

30. *See* Adam B. Jaffe et al., *A Tale of Two Market Failures: Technology and Environmental Policy*, 54 ECOLOGICAL ECON. 164, 165 (2005).

detrimental activities are well studied and documented, and numerous solutions, from regulation to Pigouvian taxes, have been proposed and sometimes implemented.[31]

Though less well-recognized, positive externalities also play a role in the production of greater environmental degradation than is socially optimal. Positive externalities refer to social benefits produced by a private entity's activity for which the individual is not fully compensated.[32] The development and creation of environmentally beneficial technology produces positive externalities because firms implementing environmentally beneficial innovation do not reap the full social, health, or environmental benefits produced by the environmental improvement caused by the technology.[33] Implementing environmental innovation that reduces pollution, improves remediation, enhances conservation, or otherwise provides environmental benefit has substantial salutary effects throughout society, far beyond the individual or firm that implements the innovation. Environmental innovation thus suffers twin public goods market failure problems—the innovation market failure and the environmental externality market failure.[34]

The environmental market failure is even more significant than this first-order innovation issue. In addition to the under-incentivization related to the initial invention of environmentally beneficial technology, a profit-maximizing firm also will not implement existing environmentally beneficial innovation to the socially optimal extent. Because firms cannot capture the full social benefits that arise from implementing environmentally beneficial technology, they do not face socially optimal incentives to implement.[35] Firms are financially incentivized by potential private operational savings, but not by potential environmental enhancement or its consequent social benefits. Private firms, therefore, will not pay

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31. *See e.g.*, BRETT M. FRISCHMANN, INFRASTRUCTURE: THE SOCIAL VALUE OF SHARED RESOURCES (2012); Reyer Gerlagh, Snorre Kverndokk, & Knut Einar Rosendahl, *Optimal Timing of Climate Change Policy: Interaction Between Carbon Taxes and Innovation Externalities*, 43 ENVTL. & RESOURCE ECON. 369, 370–73 (2009) (discussing gap between efficient carbon taxes and Pigouvian taxes).

32. Frischmann & Lemley, *supra* note 27, at 262.

33. *See* FRED BOSSELMAN ET AL., ENERGY, ECONOMICS AND THE ENVIRONMENT 41–44 (2000) (describing the role of externalities in environmental protection); Taylor et al., *supra* note 1, at 348 (noting that industry tends to under-invest in "environmental technologies because [of] their public good characteristic").

34. *See* Jaffe et al., *supra* note 30, at 165–66 (discussing dual market failures in environmental protection); Popp et al., *supra* note 27, at 1 ("Because the benefits of environmental technologies tend to accrue to society at large, rather than the adopter of such technologies, market forces alone provide little incentive for developing environmental technologies.").

35. MERGES ET AL., *supra* note 10, at 12–13.

the full social value for environmentally beneficial innovation. Consequently, environmental innovators do not receive socially accurate price signals or optimal incentives to produce environmentally beneficial innovation in the first instance. As a result, little environmentally beneficial innovation will occur.[36]

Several environmental statutes attempt to ameliorate this problem through industry incentives or technology-forcing regulations.[37] Technology-forcing laws seek to ratchet up pollution or protection standards beyond current technology capability in an attempt to force firms to develop improved environmentally protective technology.[38] While certain industry incentives and subsidies for environmentally beneficial activities have been helpful, technology-forcing laws and regulations generally have been unsuccessful and functionally unable to significantly drive environmentally beneficial innovation.[39] In certain circumstances, technology-forcing regulation has even counterproductively limited technological innovation by locking in extant technology and eliminating incentives for improvement.[40] Empirical evidence, on the other hand, indicates that significant amounts of environmentally beneficial research and development investment, and subsequent innovation, have been produced where there are private price incentives for such innovation.[41]

IV. TOWARDS SOLVING THE TWIN MARKET FAILURES OF PUBLIC GOODS INNOVATION

For a legal regime to provide socially accurate incentives for environmentally beneficial innovation, the regime has to solve both public goods market failures identified above—the innovation market

36. *See* Adler, *supra* note 1, at 36–40; Driesen, *supra* note 1, at 514–20.

37. Examples include the Safe Drinking Water Act, 42 U.S.C. §§ 300f-300j-26 (2012); Clean Water Act, 33 U.S.C. §§ 1251–1388 (2012); the Resource Conservation and Recovery Act, 42 U.S.C. §§ 6901–6992k (2012); and the Clean Air Act, 42 U.S.C. §§ 7401–7671q (2012).

38. ZYGMUNT J.B. PLATER, ROBERT H. ABRAMS, WILLIAM GOLDFARB, ROBERT L. GRAHAM, LISA HEINZERLING, & DAVID A. WIRTH, ENVIRONMENTAL LAW AND POLICY: NATURE, LAW, AND SOCIETY 743–71 (3rd ed. 2004).

39. *See* Adler, *supra* note 1, at 36–40; Driesen, *supra* note 1, at 514–20; Jaffe, *supra* note 1, at 476–85; Jänicke & Lindemann, *supra* note 1, at 129; Szarka, *supra* note 1, at 93–102; Taylor, *supra* note 1, at 350; Envtl. Law Inst., *supra* note 1; *see generally* Jaffe et al., *supra* note 30, at 168–73 (discussing how technology-forcing regulation currently is functionally unable to significantly drive environmentally beneficial innovation).

40. Adler, *supra* note 1, at 40.

41. *See* Jaffe et al., *supra* note 1, at 475; Richard G. Newell, *The Role of Markets and Policies in Delivering Innovation for Climate Change Mitigation*, 26 OXFORD REV. ECON. POL'Y 253, 255–60 (2010).

failure and the positive environmental externality market failure.[42] These market failure problems interact in ways that make traditional solutions, such as intellectual property law or subsidies to engage in environmentally beneficial activities, generally insufficient to produce socially accurate demand signals for environmentally beneficial innovation.

As discussed, both market failures are caused by externalities—externalities produced by the positive spillovers of innovation and environmental improvement. The classic means for solving externality problems is to internalize the externalities.[43] Legal regimes that bring private innovators' incentives to innovate more in line with the actual social value of their potential environmentally beneficial innovation can internalize the externalities of innovation and environmental improvement. Placing private innovators' incentives in accord with the social value of innovation will lead private innovators to engage in a more socially optimal level of innovative effort.[44] While existing intellectual property and environmental law fail to achieve these goals, such internalization could be achieved through an innovation rewards system for environmentally beneficial innovation.

The analysis below presents the framework for an original innovation rewards system for environmentally beneficial innovation and addresses likely questions and concerns about such a system. The discussion provides the conceptual basis for an innovation rewards system and makes the initial case for its feasibility, recognizing that actual implementation raises certain political and administrative challenges that are beyond the scope of this Article.

A. An Innovation Rewards System

An innovation rewards system would represent a significant shift from the current patent regime. Under a standard patent rewards system, the government acquires rights to otherwise patent-eligible subject matter that meets standard patent validity requirements[45] and, in exchange, financially compensates the inventor

42. Jaffe et al., *supra* note 30, at 168; Popp et al., *supra* note 27, at 4–6.

43. *E.g.*, Hanoch Dagan & Michael Heller, *Conflicts in Property*, 6 THEORETICAL INQUIRIES IN LAW 37, 6–7 (2005); Popp et al., *supra* note 27, at 2.

44. POSNER, *supra* note 9, at 44.

45. The patent validity requirements are utility, novelty, nonobviousness, adequate disclosure, and proper subject matter. 35 U.S.C. §§ 101–03; Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141, 149–50 (1989).

directly instead of granting the inventor a patent.[46] The invented subject matter is then made available for use by the general public, either for free or for a nominal fee. Under traditional rewards proposals, compensation is based on the inventor's expected profit.[47] For the environmentally beneficial innovation rewards system introduced here, compensation instead would be based on the expected human health and environmental benefit provided to society by the invention.[48] This value may be more difficult to measure, but it is designed to produce more accurate demand signal incentives.

The proposed innovation rewards system would shift a private inventor's expected invention profits from compensation based on market profits to compensation based on the social benefit provided by the innovation. This shift would accomplish the desired goal of significantly internalizing the positive externalities of environmentally beneficial innovation. The innovation rewards system would bring private incentives to produce environmentally beneficial innovation more in line with its social value, thereby giving inventors more socially optimal incentives to innovate.

Rewards systems in general have been the subject of a number of scholarly proposals.[49] Such systems are commonly referred to as "patent rewards" systems. The term "patent rewards," however, is a bit of a misnomer because there is nothing about such systems that is based in patent protection—they do not provide for exclusionary rights. In fact, the systems often provide just the opposite, placing the subject matter of the invention directly into the public domain.[50] For

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46. *See* Steve P. Calandrillo, *An Economic Analysis of Intellectual Property Rights: Justifications and Problems of Exclusive Rights, Incentives to Generate Information, and the Alternative of a Government-Run Reward System*, 9 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 301, 306–07 (1998) (discussing the elements of a patent rewards system). A rewards system was favored by George Washington and Alexander Hamilton at the time the Constitution was being drafted—views that did not prevail.

47. *See, e.g.*, Guell & Fischbaum, *supra* note 23, at 221 (discussing a patent rewards system for prescription drugs with the reward to the inventor based on the net present value of what the patent would have generated on the market).

48. *See, e.g.*, Steven Shavell & Tanguy van Ypersele, *Rewards Versus Intellectual Property Rights*, 44 J.L. & ECON. 525, 534–35 (2001) (proposing a patent rewards system with the reward based on the "lowest possible social surplus" provided by the invention, although still based on the quantity of invented product demanded).

49. *See, e.g.*, Abramowicz, *supra* note 24; Guell & Fischbaum, *supra* note 23; Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. ECON. 1137 (1998); Douglas Gary Lichtman, *Pricing Prozac: Why the Government Should Subsidize the Purchase of Patented Pharmaceuticals*, 11 HARV. J.L. & TECH. 123 (1997); Shavell & van Ypersele, *supra* note 48; *see also*, Fiona Murray, Scott Stern, Georgina Campbell & Alan MacCormack, *Grand Innovation Prizes: A Theoretical, Normative, and Empirical Evaluation*, 41 RES. POL'Y 1779 (2012) (discussing the incentives of innovation prizes).

50. *See, e.g.*, Shavell & van Ypersele, *supra* note 48, at 537.

this reason, "innovation rewards" is a more appropriate term and is accordingly adopted here.

Innovation rewards systems are often promoted on the basis that they can reduce or eliminate the consumer deadweight loss produced by the traditional grant of patent rights.[51] As described above, a traditional exclusionary patent grant enables the patent owner to charge a monopoly price for the invention.[52] This pricing causes consumer deadweight loss due to certain firms or consumers who value the invention above its cost of production nevertheless forgoing purchase and use of the invention due to the elevated monopoly price. A rewards system reduces or eliminates this deadweight loss because it eliminates monopoly-pricing power.[53] More critically, by reducing the cost of rewards products to near their cost of production, an innovation rewards system will increase the production of environmentally beneficial technology closer to its socially optimal level.

Innovation rewards systems, in general, produce other benefits beyond reducing deadweight loss. Rewards systems, for instance, reduce the inefficiency of firms expending resources to invent around competitors' exclusionary patents rights.[54] Because the rewards invention is available to all, there is no need to avoid competitors' patents in research or commercialization. Rewards systems also reduce the transactions costs of licensing patent rights and, concomitantly, reduce the risk and cost of inefficient patent thickets.[55]

An innovation rewards system for environmentally beneficial innovation will provide both the general rewards system benefits identified above and the additional benefit of potentially internalizing the positive externalities of environmentally beneficial innovation. This shift would also apply to other public goods innovation whose implementation produces significant positive externalities beyond the implementing firm or the consumer. Innovation rewards can thus ameliorate both the innovation market failure and the positive environmental externality market failure, resulting in substantially

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51. *See, e.g.*, Abramowicz, *supra* note 24, at 132–33 ("[T]he patent buyout benefits society as a whole by eliminating deadweight loss.").

52. *See supra* Part II.

53. *See* Abramowicz, *supra* note 24, at 130–33.

54. *See id.* at 192–93. Abramowicz points out that whether a rewards system is more efficient in this regard is debatable, as placing the invention in the public domain may also lead to inefficient excessive research on improvement inventions. *Id.*

55. *See* Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, 1 INNOVATION POL'Y & ECON. 119, 119–26 (2000) (discussing patent thickets and their transactions costs).

more efficient incentives for environmentally beneficial or other public goods innovation.

B. Implementing Innovation Rewards

Although an innovation rewards system for environmentally beneficial innovation is based on a different model than traditional intellectual property law, it does not require an overhaul of the current patent system. Rather, an innovation rewards system could be implemented in parallel to existing patent law and procedure. Most inventors could still use the extant patent system to acquire exclusionary patent rights and reap market monopoly profits. But where an inventor of an environmentally beneficial innovation believes that his or her invention has significant social value in excess of expected market profits, he or she may opt into the innovation rewards system.[56] The innovation rewards system thus could be woven into the existing patent system in a complementary manner, without producing a major disruption or upsetting settled expectations. An innovation rewards system designed in this manner also would preserve the autonomy of private inventors, who would retain the right to choose which system to participate in.

The systemic risks of the proposed innovation rewards system appear manageable. If the widespread criticism of environmental law's failure to adequately promote environmentally beneficial innovation from a social efficiency perspective turns out to be unfounded, implementation of the innovation rewards proposal would have limited negative impact or cost. If environmentally beneficial innovation is already incentivized efficiently, little additional innovation would occur as a result of this proposal, and few rewards would have to be paid.[57] In this regard, the incentives provided by environmental law and by innovation rewards complement each other.

In addition, technological line drawing around the definition of "environmentally beneficial technology" should not be a significant problem. Although it is impossible to precisely define what is and what is not environmental technology, the costs of error in making such a decision are not significant. If a non-environmental technology were accidentally included in the innovation rewards system, the rewards would still be based on improved social welfare and therefore be socially beneficial. If an actual environmental technology were

56. *See* Kremer, *supra* note 49, at 1148 (suggesting an opt-in patent reward system); Shavell & van Ypersele, *supra* note 48, at 537–39 (proposing an optional patent rewards system).

57. In this case, the cost of erroneously implementing the innovation rewards system would simply be the administrative start-up costs, as discussed below.

erroneously excluded from the system, it would still be subject to the current patent system and the rewards no more misaligned than current practice. Further, because the system functions through incentives, the innovation rewards system will produce the desired signals so long as potential innovators perceive line-drawing decisions to be reasonably likely to be accurately made.

An innovation rewards system does introduce the need for an administrative body to determine the value of inventions whose owners chose innovation rewards rather than patent rights.[58] Identifying the social value produced by an invention is not an easy task. This hurdle should not be understated, but for the following reasons it is not as administratively infeasible as it may first appear.

First, there is one existing example of a rewards system in the US patent system. For national security reasons, individuals may not receive patents on atomic energy inventions.[59] Individuals who achieve atomic energy inventions, however, may receive a patent reward.[60] The reward is set by a "Patent Compensation Board," based in part upon the actual use and importance of the invention.[61] Relatedly, the US government can effectively force the compulsory licensing of patented inventions for its own use.[62] If negotiations over the value of the license fail, the government may still use the patented invention. Such action results in a takings claim by the patent owner, and a court must fix the value of the patent.[63] Thus, there is already both administrative and judicial institutional experience and expertise concerning rewards-type systems, albeit on a limited scale.

Second, a rarely noted provision of the Clean Air Act provides a carefully limited compulsory licensing system for specific environmentally beneficial technology.[64] This compulsory licensing system would act like an innovation rewards system in certain

58. These responsibilities could also be handled judicially, through proceedings akin to takings damages adjudication, although the expertise required appears to militate towards administrative responsibility being more efficient.

59. 42 U.S.C. § 2181 (2012).

60. 42 U.S.C. § 2187 (2012); Stefan Riesenfeld, *Patent Protection and Atomic Energy Legislation*, 46 CAL. L. REV. 40 (1958).

61. 42 U.S.C. § 2187(c) (2012).

62. Patent owners whose patents have been infringed by the US government have a cause of action in the Court of Federal Claims to receive compensation for the infringement. 28 U.S.C. § 1498(a) (2012). Because private plaintiffs are not entitled to injunctions against infringement by the United States, this effectively creates a compulsory licensing scheme whereby the United States may force the licensing of any patent. *See* Pitcairn v. United States, 547 F.2d 1106, 1118 (Ct. Cl. 1976) (holding that the owner of a patent infringed by the United States is only entitled to damages, not an injunction).

63. *See, e.g.*, Motorola, Inc. v. United States, 729 F.2d 765, 772 (Fed. Cir. 1984); Zoltek Corp. v. United States, 58 Fed. Cl. 688, 706–07 (2003).

64. 42 U.S.C. § 7608 (2012).

regards. The Clean Air Act permits a private party to apply to the Environmental Protection Agency and the US Attorney General to require a patent owner to license a patent for an invention that is necessary to comply with certain air emission standards.[65] To receive a compulsory license, the applicant must demonstrate that: (1) the patented device will be "used or [is] intended for public or commercial use" and is not "reasonably available," (2) no other reasonable method for complying with the emissions standards exists, and (3) failure to obtain the license would result in a "substantial lessening of competition or a tendency to create a monopoly in any line of commerce."[66] If a compulsory license is granted, the patent owner is entitled to "adequate" compensation based on the economic value of the license[67] (as opposed to the social value of the innovation, as proposed under the innovation rewards model). Though these compulsory licensing provisions have been part of the Clean Air Act since it was enacted forty years ago,[68] they apparently have never been used.[69]

A second reason that innovation rewards valuation is feasible is because the rise in the importance of intellectual property rights and prevalence of intellectual property litigation has produced a significant amount of research and expertise concerning the valuation of intellectual property rights.[70] This body of work includes several valuation methods that would be appropriate for valuing the societal benefit of public goods innovation.[71] Intellectual property valuation is

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65. 42 U.S.C. § 7608 (2012). The air emission standards pursuant to which a compulsory license may be sought are those established in 42 U.S.C. §§ 7411, 7412, and 7521.

66. 42 U.S.C. § 7608(1)–(2) (2012).

67. 40 C.F.R. § 95.4(a)(7). The license would be nonexclusive, non-assignable, and restricted in scope and duration as necessary to fulfill the Clean Air Act's emission requirements. *See* 40 C.F.R. § 95.4(a)(1)–(3).

68. Clean Air Act of 1970, Pub. L. No. 91-604, § 12(a), 84 Stat. 1676, 1709 (1970).

69. Intriguingly, the Clean Air Act appears to be the only example of a private party being able to initiate a compulsory license. In addition to the United States' general authority to force the compulsory license of a patent for government use, as discussed above, several other statutes provide specific authority for the United States to require the licensing of patented subject matter in certain circumstances. *See, e.g.*, the Plant Variety Protection Act, 7 U.S.C. § 2404 (2005) (allowing the Secretary of the Department of Agriculture to make available a patented variety to assure "adequate suppl[ies] of fiber, food, or feed" where the owner will not or cannot provide for the public needs at a reasonably fair price); the Atomic Energy Act, 42 U.S.C. § 2183 (2005) (providing for a mandatory license of a patent that claims an invention or discovery that primarily uses or produces nuclear material or atomic energy in certain circumstances).

70. *See, e.g.*, Richard Razgaitis, Valuation and Dealmaking of Technology-Based Intellectual Property: Principles, Methods, and Tools (2d ed. 2009); David S. Ruder, STRATEGIES FOR INVESTING IN INTELLECTUAL PROPERTY (2008); Céline Lagrost, Donald Martin, Cyrille Dubois, & Serge Quazzotti, *Intellectual Property Valuation: How to Approach the Selection of an Appropriate Valuation Method*, 11 J. INTELL. CAPITAL 481, 481 (2010).

71. *See, e.g.*, Razgaitis, *supra* note 70; Ruder, *supra* note 70.

hardly an exact science, but it has become much more sophisticated over the past decade.

Third, valuing environmental benefit is a practice that multiple administrative agencies already engage in, both explicitly and implicitly. Setting many regulatory standards requires balancing, in some manner, the benefit to be obtained from environmental improvement against the cost of implementing that regulation.[72] Most environmental statutes and regulations already require this, either in the form of cost-benefit balancing or in the form of determining the feasibility of certain environmental protections.[73] Indeed, regulatory agencies already routinely value environmental benefit.[74] Though cost-benefit analysis is a highly contentious and complex exercise,[75] it is still possible to get a rough handle on the social benefit of environmentally beneficial innovation in many circumstances. Importantly, this valuation does not have to be exact in order for the innovation rewards system to be highly advantageous—it only needs to provide a more accurate demand signal than the current market failures structure.

C. Innovation Rewards versus Alternative Innovation Policy

Patent rights and innovation rewards are not the only alternatives for governmental innovation policy. Commentators and experts have suggested a variety of potential options to incentivize socially beneficial innovation. A great advantage of innovation rewards over a variety of these other potential innovation policies,

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72. *See, e.g.*, Amy Sinden, *Formality and Informality in Cost Benefit Analysis*, 2015 UTAH L. REV. 93 (2015) (discussing a wide variety of environmental laws and regulations that require at least informal cost-benefit analysis).

73. *See, e.g.*, the Toxic Substances Control Act, 15 U.S.C. § 2605 (2012) (requiring the Environmental Protection Agency to engage in risk-benefit balancing to protect against "unreasonable risk" from toxic substances); the Clean Air Act, 42 U.S.C. § 7612 (2012) (requiring a feasibility-based approach to environmental protection standards); the Safe Drinking Water Act, 42 U.S.C. § 300g-1 (2012) (requiring a feasibility-based approach to national primary drinking water standards). Statutes that regulate based on any health effect (i.e., regulate to zero risk levels), such as the Delaney Clause, 21 U.S.C. § 376(b)(5)(B) (2012), or statutes that simply provide for the provision or dissemination of information, such as the Emergency Planning and Community Right-to-Know Act, 42 U.S.C. §§ 11001–50 (2012), do not require valuation of the environmental benefit received in this regard.

74. *See, e.g.*, MATTHEW D. ADLER & ERIC A. POSNER, NEW FOUNDATIONS OF COST-BENEFIT ANALYSIS (Harvard University Press 2006).

75. For strong critiques of cost-benefit analysis, see Frank Ackerman & Lisa Heinzerling, PRICELESS: ON KNOWING THE PRICE OF EVERYTHING AND THE VALUE OF NOTHING (2004) (criticizing the functionality of cost-benefit analysis, both theoretically and practically); Amy Sinden, Douglas A. Kysar, & David M. Driesen, *Cost-Benefit Analysis: New Foundations on Shifting Sand*, 3 REG. & GOVERNANCE 48 (2009) (similarly criticizing the functionality of cost-benefit analysis, both theoretically and practically).

however, is that an innovation rewards system maintains reliance on the diverse array of ideas and insights in the private market to select potential means for social benefit, identify interesting avenues for research, and decide how to conduct research and development for innovation. This decentralized approach to innovation is generally superior to attempts to centralize innovation decision-making in a governmental body in most contexts.[76] Decentralized innovation activities draw from a much broader pool of ideas, information, and innovators to explore diverse research and innovation strategies than do centralized approaches.[77]

In addition, Professors Amy Kapczynski and Talha Syed have pointed out that the current patent system creates asymmetrical incentives for inventions that are excludable.[78] Because there is not necessarily a correlation between excludability and social value, this bias can have significant negative social welfare effects.[79] The innovation rewards system developed here, on the other hand, does not rely on excludability for incentives. Rather, incentives are based on the social value of the innovation, leading such a system to provide more accurate social welfare incentives than the current model.

Other governmental innovation mechanisms that have been attempted in the environmental context generally cannot be expected to be as successful as innovation rewards. For example, direct government funding through grants or subsidies for proposed environmentally beneficial research and development requires up-front payment without any guarantee of innovation success.[80] If the proposal is not successful, the government and taxpayers have wasted scarce research resources. Grants also require that the government pick the winners of promising innovation proposals in advance, a task that is notoriously difficult.[81] Innovation is a very

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76. *See* David E. Adelman & Kirsten H. Engel, *Reorienting State Climate Change Policies to Induce Technological Change*, 50 ARIZ. L. REV. 835, 837 (2008) (discussing how private economic incentives and the "uncertainties associated with technological innovation argue against centralization in the federal government"); Adler, *supra* note 1, at 13–14 (explaining the virtue of decentralization in relation to innovation and problem-solving).

77. Suzanne Scotchmer, Innovation and Incentives 38 (2004); Nancy Gallini & Suzanne Scotchmer, *Intellectual Property: When Is It the Best Incentive System?*, *in* 2 INNOVATION POLICY AND THE ECONOMY 51, 65 (Adam B. Jaffe et al. eds., 2002).

78. Kapczynski & Syed, *supra* note 19, at 1926.

79. *Id.* at 1942.

80. *See* Daniel J. Hemel & Lisa Larrimore Ouellette, Beyond the Patent-Prizes Debate, 92 TEX. L. REV. 303, 333–45 (2014) (comparing *ex ante* grants and tax incentives to *ex post* prizes and patents); *see also* Taylor et al., *supra* note 1, at 356–59 (discussing various types of governmental incentives that have been implemented).

81. Adler, *supra* note 1, at 29 (discussing government grants); Hemel & Ouellette, *supra* note 80, at 320–21 (also discussing government grants).

complex phenomenon, and it is almost always impossible to predict what the most productive avenue of research will be *ex ante*.[82]

Similarly, standard environmental law mechanisms are not as productive as innovation rewards. Cap-and-trade, emissions taxes, and performance standards all require *ex ante* centralized understanding, to varying extents, of the most promising ways to address certain environmental problems, the likely rate of success in addressing the problems, and the course of technological development.[83] Further, each of these mechanisms only address the environmental externality market failure in environmentally beneficial innovation, not the innovation market failure. These systems leave the risk of necessarily incomplete foresight on society, in contexts that may require predictions concerning environmental and technological effects decades into the future. Innovation rewards should function far better in this regard, providing a system that can harness the power of decentralized knowledge and innovation and that naturally changes course and adjusts as new environmental problems arise or fade and novel, unforeseen technologies emerge. Innovation rewards should be both more nimble and more efficient in seeking environmentally beneficial advances.

In a particular innovation context, Professor Jonathan Adler has proposed the introduction of patent prizes as a means to reduce greenhouse gas emissions in an effort to address climate change.[84] A patent prize involves a public or private entity offering a set prize for a pre-specified technological achievement, such as the X-Prize Foundation's offer of $10 million for the first privately developed, reusable, manned spacecraft.[85] While Adler's patent prize proposal has numerous virtues, it has several drawbacks relative to innovation rewards in general. Prizes can only function if one can identify a specific problem and provide specific criteria for a prize *ex ante*. Because technological development is a highly uncertain, unpredictable process and our current understanding of the means to provide environmental benefit may be limited, defining criteria *ex ante* could problematically limit the scope of innovation that is explored and the areas of potential benefit.[86] That said, pursuing an innovation rewards system would not foreclose taking advantage of other environmentally beneficial mechanisms simultaneously.

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82. Scotchmer, *supra* note 77, at 49; Adler, *supra* note 1, at 32.

83. *See* Adler, *supra* note 1, at 37; Hemel & Ouellette, *supra* note 80, at 328–29.

84. *See* Adler, *supra* note 1, at 42–45.

85. *See* Adler, *supra* note 1, at 12–13; Hemel & Ouellette, *supra* note 80, at 317–19.

86. *See also* Roin, *supra* note 19, at 1034–38 (framing other critiques of prize systems).

D. Innovation Rewards Challenges

Despite the various advantages mentioned above, an innovation rewards system is hardly a perfect tool. There are four standard criticisms leveled against patent rewards systems in general: (1) that they fail to incentivize commercialization (i.e., distribution) of inventions, as opposed to simply incentivizing invention; (2) that rewards based on marginal costs do not adequately reward or, therefore, adequately incentivize inventors for fixed costs; (3) that opt-in rewards systems do not weed out invalid patents; and (4) that administering rewards systems is costly.[87] With the exception of the final concern, these critiques either can be resolved or are not pertinent to the innovation rewards system proposed here.

First, for environmentally beneficial innovation, there should not be a failure in commercialization from an innovation perspective. Environmentally beneficial innovation will either be cost-effective or cost-detrimental for potential implementers, such as industry actors. Cost-effective environmentally beneficial innovation, such as innovation that reduces consumptive resource needs, is expected to be adopted by consumer firms as a matter of course due to competitive market pressures.[88] Environmentally beneficial innovation that increases net operational expenses, on the other hand, will only be adopted as the result of governmental regulation (whether feasibility-based, command-and-control, or another regulatory mechanism) or a combination of market and consumer pressure.[89] In the standard course of environmentally beneficial innovation, government regulation or market effects will force (or not force) commercialization of the innovation independent of the intellectual property regime in place. In other words, to the extent environmentally beneficial innovations would not be implemented under an innovation rewards system, they would not be implemented outside of an innovation rewards system either.

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87. Abramowicz, *supra* note 24, at 172–211; *see also* F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697, 710 (2001) (critiquing patent rewards systems for their failure to efficiently incentivize commercialization of inventions).

88. *Cf.* Marian Beise & Klaus Rennings, *Lead Markets and Regulation: A Framework for Analyzing the International Diffusion of Environmental Innovations*, 52 ECOLOGICAL ECON. 5, 14–16 (2005) (discussing the role of market factors in environmental policy and innovation). *But see* Linda Greer & Christopher Van Löben Sels, *When Pollution Prevention Meets the Bottom Line*, 31 ENVTL. SCI. TECH. 418A (1997) (case study revealing that firms may not implement pollution and waste reducing operations even where such implementation may be cost efficient).

89. Timothy F. Malloy, *Regulating by Incentives: Myths, Models, and Micromarkets*, 80 TEX. L. REV. 531, 586–87 (2002).

Innovation rewards, however, add an incentive for implementation beyond the status quo. Under an innovation reward system, the inventor is only compensated based on the social benefit of the innovation and therefore only for actual use of the innovation. Innovation rewards provide inventors with strong incentives to encourage industry adoption of their environmentally beneficial technology, whether through market, consumer, or political pressure. The innovation rewards system thus introduces greater incentives to disseminate environmentally beneficial technology in addition to the incentives to invent it creates in the first instance.[90]

While a common critique of existing intellectual property law is that it does not sufficiently promote the diffusion of new technology,[91] the inherent design of innovation rewards for environmentally beneficial technology confronts this long-standing problem. Although the proposed innovation rewards system internalizes the positive externalities of environmentally beneficial *innovation*, it does not directly internalize the positive externalities of environmentally beneficial *technology*. The difference between these two types of internalization is that under the rewards system, environmentally beneficial innovators can reap the rewards of the social benefit produced by their innovation, but implementing firms may still face positive externalities with respect to the adoption of such innovation. As noted above, however, in addition to regulation and consumer market pressure, the financial carrot of innovation rewards presents a surplus that an innovator would be incentivized to share with potential implementing firms to promote greater adoption. Thus, as a result of private market transactions, the innovation rewards system should provide socially optimal incentives for both environmentally beneficial innovation and implementation, the former directly and the latter indirectly.

As to the second general critique of rewards systems, under the innovation rewards system proposed here, rewards are not based on pricing the invention at its marginal cost, but rather at its social value.[92] Proper incentives are thus created. Relatedly, this proposal would weed out unworthy patents both because innovation rewards

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90. Innovation rewards for environmental innovation that is not implemented will be low or zero, as rewards are based on the social benefit produced by the invention. These understandings highlight that patent incentives alone will not lead to widespread adoption of environmentally beneficial innovations that significantly increase operations costs. Regulatory requirements or market/consumer influences will also be necessary. *See* Taylor et al., *supra* note 1, at 371–72 (finding that patenting of environmentally beneficial innovation is relatively limited in the absence of governmental regulation stimulating the market).

91. Adler, *supra* note 1, at 3; Hall & Helmers, *supra* note 5, at 490.

92. *See supra* Part IV.A.

are only available for innovation that satisfies standard patent validity requirements and because inventors will only be rewarded based on the social value provided by their invention.

The final critique of the innovation rewards system concerns the cost of administering the system. Though these costs cannot be ignored, they are not necessarily prohibitive. A rewards system creates two types of costs: the costs of administering the system and the cost of the rewards themselves. The most significant administrative cost of the proposed rewards system is likely the resources that will be required to calculate the social value provided by environmentally beneficial innovations. As discussed, substantial private and public resources have already been devoted to developing frameworks for accomplishing this task, both pursuant to existing environmental laws and regulations and due to the increased role that intellectual property assets play in the market.[93] In addition, the added cost of expanding the existing Patent Compensation Board to handle environmental innovation, though not *de minimis*, pales in comparison to the potential benefit of offering substantially more efficient incentives for technological innovation with environmental benefits.[94] Finally, the financial innovation rewards provided under the proposed system can be reduced by the cost of administering the rewards system. This offset would result in an economically efficient transaction cost—the social benefit provided by an invention is reduced by the cost of administering rights in the invention, whether through traditional patent rights or innovation rewards—and to a certain extent will allow the rewards system to pay for itself in terms of net social welfare. This is an accomplishment that the current patent system does not achieve.

Determining the precise social value of an innovation would be an impossible task. Not only would it require calculating to what extent society benefits from particular environmentally beneficial innovation, but it would also require analysis of numerous second-order effects. These include, but are not limited to, economic and incentive distortions caused by the potential grant of a reward, rent dissipation from multiple inventive efforts at various stages of invention, and determination of the value of the invention for its

93. *See supra* Part IV.B.

94. The cost of administering rewards would include the reality that such administration could not be expected to occur in a fully efficient manner. In reality, administrative agency operation often contains multiple flaws. *See, e.g.*, Abramowicz, *supra* note 24, at 147 (discussing critiques of rewards system efficiency due to potential agency capture and undue executive influence).

impact and contribution to future innovation and technological development.[95]

These challenges and spillover complications, however, do not indicate that approximate or partial valuation would not provide viable enough incentive signals to produce substantially greater social welfare than the current system. First, so long as rewards are not systematically skewed to be either too high or too low—that is, as long as rewards average the appropriate valuation and inventors have no *ex ante* knowledge of how their invention will be treated—innovation rewards will provide accurate incentives. More importantly, there is no reason to expect that the market values innovation in general more accurately than a rewards system would. In the case (as here) where there are significant externalities that result from the use of environmentally beneficial innovation, the market is expected to value the innovation much less accurately than an innovation rewards system. In order to be beneficial, valuation under a rewards system does not have to be perfect; it only needs to be accurate enough to make up for any increased administrative cost of the system. Considering the substantial positive externalities of environmentally beneficial innovation, this appears to be an attainable goal, rendering the proposed rewards system a desirable "second-best" reform.[96]

The cost of paying rewards to inventors likely will be significant as well. The rewards will be based on the social benefit provided by an environmentally beneficial innovation, and inventions with significant environmental benefit may be worth a substantial social amount. Importantly, however, so long as the system is administered properly, the grant of rewards by definition will be social welfare efficient. The government will not pay more for a reward than what it is worth socially. To the extent taxes are increased (for example, to pay for the rewards), such taxation will result in a net improvement in societal welfare.[97] Further, the payment of innovation rewards could be spread out over time. For example, the system could provide innovators with an annual payment based on the

95. Frischmann & Lemley, *supra* note 27, at 268–71; *see also* Gregory N. Mandel, *Proxy Signals: Capturing Private Information for Public Benefit*, 90 WASH. U.L. REV. 1, 47–49 (2012) (discussing the dynamic effects of innovation).

96. *See* Lori Snyder Bennear & Robert N. Stavins, *Second-Best Theory and the Use of Multiple Policy Instruments*, 37 ENVTL. & RES. ECON. 111 (2007) (discussing the value of adopting "second-best" policies in the context of environmental market failures); Richard G. Richels, Geoffrey J. Blanford, & Thomas F. Rutherford, *International Climate Policy: A "Second Best" Solution for a "Second Best" World?*, 97 CLIMATE CHANGE 289 (2009) (discussing the value of adopting "second-best" policies to address environmental challenges).

97. ALLAN M. FELDMAN & ROBERTO SERRANO, WELFARE ECONOMICS AND SOCIAL CHOICE THEORY 146–56 (2d ed. 1980).

social benefit accrued over the prior year.[98] The payment of rewards could also be capped, either at a fixed amount or over a fixed time (like the current patent system).[99] Because of the level of uncertainty inherent both in innovation and in the status of competitor innovation, it is likely that reward caps (albeit set at a relatively high level) would have only a negligible negative effect on incentives to innovate in environmentally beneficial technology.

Further, as discussed above, an innovation rewards system will increase production of environmentally beneficial technology, reduce deadweight loss in the consumption of the technology,[100] and incentivize greater dissemination of the technology. Because of the second-order positive spillovers of implementing environmentally beneficial innovation, these effects are significant and will help to offset the cost of innovation rewards.

A rewards system will also create other varieties of cost savings. Promoting greater environmentally beneficial innovation should produce administrative savings in other areas. For example, various environmental regulations may become easier to administer and enforce as a result of environmental innovation. An innovation rewards system will also reduce redundant research efforts, as firms will no longer have to invent around competing firms' patents.[101] In addition, the rewards system will reduce licensing transaction costs and both the risks and costs of patent thickets.[102]

Though the foregoing analysis attempts to make the positive case for an innovation rewards system, innovation rewards should not be considered a panacea. In addition to the administrative cost of implementation and the challenge of accurately evaluating rewards, there would be other inefficiencies and difficulties with such a system.

First, a rewards system would lead to society paying more for certain environmental innovation than is necessary. While basing innovation rewards on the social benefit of innovation would send the accurate demand signals to potential innovators, in certain situations innovators would be willing and able to produce environmental innovation for a lesser reward. That is, even though an innovation

98. *See* Roin, *supra* note 19 (discussing the advantages of an incentive system that awards innovators over time to adjust for changes in the social value of the innovation). Paying rewards over time would also reduce the cost of errors in rewards calculations, for example where a technology thought to be environmentally beneficial later turns out to have detrimental effects. *See, e.g.*, Pål Börjesson, *Good or Bad Bioethanol from a Greenhouse Gas Perspective—What Determines This?*, 86 APPLIED ENERGY 589 (2009) (discussing the science concerning the deleterious effects of ethanol, once thought to be beneficial, on the environment).

99. 35 U.S.C. § 154 (2012).

100. Abramowicz, *supra* note 24, at 126.

101. *Id.*

102. *Supra* Part IV.A.

rewards system would produce an accurate demand signal for environmentally beneficial innovation, it is likely that in certain circumstances a weaker signal would still incentivize equivalent innovation.[103] It is impossible to know *ex ante*, however, which environmentally beneficial innovation needs a "full" demand signal in order to promote its innovation, and often impossible even in hindsight to know how much of an incentive was necessary to produce certain innovation.[104] In circumstances where a weaker signal could have produced the same level of innovation, society ends up paying greater innovation rewards than was necessary to achieve a given level of environmental benefit.

Second, the innovation rewards system raises concerns of political pressure and agency capture regarding the valuation of awards.[105] Innovating firms will try to convince the administrative bodies that determine awards to value their innovations as highly as possible. Some firms will try to accomplish this objective not only through acceptable evidentiary means, but also by asserting political pressure on innovation reward examiners or through endeavoring to have sympathetic evaluators appointed in the first instance. Though this concern is legitimate, it is one faced throughout administrative practice, and traditional means of trying to insulate administrative bodies from political pressure and industry bias will need to be implemented in order to minimize any negative effects.[106] For example, the identity of the individuals evaluating a particular award

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103. *See, e.g.*, Michael Abramowicz & John F. Duffy, *The Inducement Standard of Patentability*, 120 YALE L.J. 1590 (2011) (discussing the degree of incentives necessary to induce innovation). In a related vein, there could be a concern that offering a monetary reward for environmentally beneficial innovation could dissuade otherwise altruistic inventors from taking part in such innovation activity due to the blatant commercialization of such activity. *See* Simone A. Glynn et al., *Attitudes Toward Blood Donation Incentives in the United States: Implications for Donor Recruitment*, 43 TRANSFUSION 7 (2003) (finding that certain types of monetary incentives may reduce blood donations). However, it seems unlikely that a shift from the traditional patent system to the potential for innovation rewards would have such an effect on altruistic innovators in this context. To the extent this concern seems considerable, other types of rewards and recognition could be offered as alternative options.

104. *See* Gregory N. Mandel, *Patently Non-Obvious II: Experimental Study on the Hindsight Bias Issue before the Supreme Court in KSR v. Teleflex*, 9 YALE J.L. & TECH. 1 (2007) (discussing the problem of hindsight bias); Gregory N. Mandel, *Patently Non-Obvious: Empirical Demonstration that the Hindsight Bias Renders Patent Decisions Irrational*, 67 OHIO ST. L.J. 1391, 1400-03 (2006) (also discussing the problem of hindsight bias).

105. *See* Alan Schwartz, *Statutory Interpretation, Capture, and Tort Law: The Regulatory Compliance Defense*, 2 AM. L. & ECON. REV. 1, 39–41 (2000) (discussing concerns of political pressure and agency capture in regulation); Richard B. Stewart, *The Reformation of American Administrative Law*, 88 HARV. L. REV. 1669, 1684–86 (1975) (discussing the concern of administrative agency capture).

106. *See* Rachel E. Barkow, *Insulating Agencies: Avoiding Capture Through Institutional Design*, 89 TEX. L. REV. 15, 42–64 (2010) (discussing and introducing methods for insulating administrative agencies from capture).

could be kept confidential, multiple examiners could independently evaluate each award, and various analytic best practices for award valuation could be employed.

Third, an innovation rewards system could have dynamic second-order effects concerning innovation that would be very difficult to take into account and accurately price. An innovation rewards system along the lines introduced above is expected to create greater incentives for environmentally beneficial innovation, or other public goods innovation, than currently exist. Such incentives could lead flexible potential innovation producers to shift their efforts from research and development efforts in other industries to environmentally beneficial innovation.[107] To the extent an innovation rewards system reduces innovation in other fields, such costs, which would be difficult to measure, would need to be taken into account when pricing rewards. That said, to the extent the rewards are set efficiently, these effects will be efficient as well.

The innovation rewards inefficiencies discussed here, although important to consider, are hardly fatal to the proposal. As discussed above, existing innovation and environmental law suffer from their own varieties of these problems as well as significant additional market failures. Thus, the challenge is not having to establish a perfect innovation rewards system, but rather producing a rewards system that is better than the current model. Considering the variety of incentive and efficiency benefits that an innovation rewards system can provide, its advantages appear likely to outweigh the costs of implementation and potential inaccuracy in evaluation of rewards.

E. International Innovation Rewards

The innovation rewards system introduced above need not be limited to the domestic law context. Such an innovation rewards system could also have significant implications for addressing international environmental challenges. The market failures in environmental and intellectual property law that limit environmentally beneficial innovation are both exacerbated in the international context. On the environmental side, even where the positive spillovers of environmentally beneficial innovation may be

107. *See* Richard C. Levin, Alvin K. Klevorick, Richard R. Nelson, & Sidney G. Winter, *Appropriating the Returns from Industrial Research and Development*, 18 BROOKING PAPERS ON ECON. ACTIVITY 783 (1987).

accounted for to some extent in domestic law, the international social welfare benefits are essentially never taken into account.[108]

Similarly, on the innovation side, despite significant global harmonization of the substance of patent law, patent rights remain primarily domestic law.[109] This legal reality means that even if domestic patent protection permits an inventor to capture significant (domestic) social benefits of their innovation, absent obtaining patent protection in multiple jurisdictions around the world, inventors lack accurate demand signals on an international basis. This means that even well-functioning domestic patent law does not solve the innovation market failure from a global perspective, even if one temporarily ignores the consumer deadweight loss of exclusionary patent rights.

An international agreement to develop an international innovation rewards system therefore could have substantial social welfare benefits. Because the environmental and health benefits would be so extensive when considered across a global population, rewards that compensate innovation even at a fraction of its global social benefit could produce substantial incentives for environmentally beneficial innovation—incentives far greater than currently exist. Countries may be willing to contribute to the funding of such an innovation rewards system because the benefits could far outweigh any individual country's costs. Due to the pooling of resources, this may be a very cost-efficient mechanism for achieving environmental innovation on a global scale.[110]

International innovation rewards could be particularly beneficial for spurring environmental innovation in developing countries and in other contexts with less economically well-off consumers, where private free-market incentives are generally very low due to the twin market failures of environmentally beneficial innovation.[111] Innovation rewards could provide a more practical system to address certain intractable international environmental challenges, such as climate change,[112] rather than zero-sum negotiations over who pays for amelioration.

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108. David Held, *Climate Change, Global Governance, and Democracy: Some Questions*, *in* CANNED HEAT: ETHICS AND POLITICS OF GLOBAL CLIMATE CHANGE 17 (M. Di Paola & G. Pellegrino eds., 2014).

109. Jerome H. Reichman & Rochelle Cooper Dreyfuss, *Harmonization Without Consensus: Critical Reflections on Drafting a Substantive Patent Law Treaty*, 57 DUKE L.J. 85, 88 (2007).

110. Funding shares could be based in proportion to domestic social benefit, for example, or could be distributed based on other factors, such as country wealth.

111. *See* Adler, *supra* note 1, at 17.

112. *See* Adler, *supra* note 1, at 19 (discussing the use of technology inducement prizes to address climate change challenges).

V. CONCLUSION

An innovation rewards system can simultaneously solve the twin public goods market failures resulting from both the non-rivalrous and non-excludable nature of innovation and the positive externalities of environmentally beneficial technology. Proponents of patent rewards systems in other contexts have noted that, despite the potential for increasing social welfare, implementation of rewards systems often remains a challenge because rewards systems represent a more radical shift from extant patent law than is usually politically feasible.[113] The innovation rewards system for environmentally beneficial innovation proposed here, however, provides a more incremental change than many proposals by implementing rewards solely for certain technological subject matter and preserving private inventor autonomy to choose to opt into the system or not. Consequently, this proposal may be less politically charged and more salient than an overhaul of the patent system.

Given that certain resistance to a rewards system is expected, both from special interests (such as, perhaps, the patent bar)[114] and due to a status quo bias,[115] an innovation rewards system focused on a specific subject matter with particularly evident societal benefits may offer the strongest case for an opportunity to test a rewards system. Environmentally beneficial innovation meets these requirements because it provides benefits not only through reducing deadweight loss, transactions costs, and patent thicket inefficiency, but also through producing potentially vast positive externalities as a result of environmental innovation with widespread human health, environmental, and societal benefits. If this innovation rewards proposal is successful in the environmentally beneficial technology context, it may be extended to address innovation concerning other public goods that similarly suffer these twin market failures.

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113. Abramowicz, *supra* note 24, at 211–12.

114. *Id.* Though the patent validity of an innovation rewards invention would need to be determined, as discussed above, the need for technology licensing work and any litigation related to innovation that is the subject of innovation rewards would be substantially reduced.

115. *See* Daniel Kahneman, Jack L. Knetsch & Richard H. Thaler, *Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias*, 5 J. ECON. PERSPECTIVES 193, 194 (1991) (defining and explaining the status quo bias).