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PLEDGING PATENTS FOR THE PUBLIC GOOD: RISE AND FALL OF THE ECO-PATENT COMMONS

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ABSTRACT

Commons and pledge structures have been used to achieve various goals of patent holders, including the advancement of social and philanthropic aims. This Article, for the first time, analyzes the formation and structure of a widely acclaimed effort to pool patents for the promotion of green/clean technologies—the Eco-Patent Commons (EcoPC)—as well as its actual impact on technology diffusion and the factors leading to its demise in 2016. We combine quantitative econometric techniques with qualitative interviews to paint the most complete picture of this innovative

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This research was financially supported by the Centre for International Governance Innovation (CIGI), Waterloo, Ontario, Canada. Contreras also acknowledges support from the University of Utah Albert and Elaine Borchard Fund for Faculty Excellence. The authors thank Bassem Awad, Hans-Jochen Banhardt, Joshua Sarnoff, Amol Joshi, and the participants in the 2017 Patent Pledges Workshop at American University Washington College of Law (which was conducted with financial support from Google, Inc.), the 6th Annual Roundtable on Standard Setting Organizations and Patents at the Searle Center at Northwestern University, and the 2019 Works in Progress in Intellectual Property (WIPIP) Colloquium at the University of Houston Law Center for their valuable discussion, feedback and input on this article. The authors also thank each person who generously agreed to be interviewed for this article. The authors declare no conflicts of interest. Research assistance by Jessica Van Waggoner and Luke Hanks is greatly appreciated.

and ambitious effort to date. Our quantitative results show that the patents contributed to the EcoPC were, on average, less cited than comparable patents, and that the contribution of these patents to the EcoPC did not increase their rates of citation. Moreover, there is no evidence that the availability of these patents through the EcoPC increased the diffusion of pledged inventions. Our interviews revealed significant structural and organizational issues that limited both the attractiveness of the EcoPC to new participants and its value to potential users of pledged technology. Our findings have implications for the effectiveness of patent commons in enabling the diffusion of patented technologies more broadly.

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I. INTRODUCTION

The role of patents in promoting, or hindering, the mitigation of global climate change and environmental degradation is uncertain and increasingly contested. In Vice President Al Gore's 2017 film, *An Inconvenient Sequel: Truth to Power*,[1] Mr. Gore portrays the negotiations leading up to the 2015 Paris Agreement on international climate change.[2] In one segment, he focuses on a standoff between the government of India, a major carbon emitter, and other countries. In attempting to mediate the standoff, Mr. Gore seeks to broker a trade: India would give up its national coal power plan, and U.S. tech company SolarCity would pledge its solar technology patents for royalty-free use in the developing world.[3] This commitment of patents would, presumably, enable India to implement environmentally friendly solar technology in lieu of its carbon-spewing coal-powered plants.

According to the film, the SolarCity patent pledge was inspired by a similar commitment made by Elon Musk, the outspoken CEO of Tesla Motors.[4] In 2014, Musk famously blogged that "All Our Patent Are Belong To You," seemingly contributing Tesla's valuable patent portfolio to the world at no cost.[5] Though it remains unclear whether SolarCity ever pledged its patents and

1. AN INCONVENIENT SEQUEL: TRUTH TO POWER (Participant Media and Actual Films 2017).

2. Framework Convention on Climate Change, *Adoption of the Paris Agreement*, ¶ 1, U.N. Doc. FCCC/CP/2015/10/Add.1 (Jan. 29, 2016).

3. SolarCity is reported to have a substantial patent portfolio. *See* Matthew Rimmer, *Elon Musk's Open Innovation: Tesla, Intellectual Property, and Climate Change*, *in* INTELLECTUAL PROPERTY AND CLEAN ENERGY 515, 540–41 (Matthew Rimmer ed., 2018).

4. Tesla acquired SolarCity in 2016 for approximately $2 billion. Prior to the acquisition, Musk was the chairman of SolarCity and the cousin of its CEO Lyndon Rive. Danielle Muoio, *It's Official: Tesla's Acquisition of SolarCity Has Closed*, BUS. INSIDER (Nov. 21, 2016, 9:52 AM), https://www.businessinsider.com/tesla-solarcity-deal-closes-2016-11 [https://perma.cc/3JA2-GRK2].

5. Elon Musk, *All Our Patent Are Belong To You*, TESLA (June 12, 2014), https://www.tesla.com/blog/all-our-patent-are-belong-you [https://perma.cc/PQ6D-P47Q]; *see also* Jorge L. Contreras, *Patent Pledges*, 47 ARIZ. ST. L.J. 543, 544–45 (2015) [hereinafter Contreras, *Patent Pledges*] (introducing Tesla pledge); Jorge L. Contreras, *The Evolving Patent Pledge Landscape*, CTR. FOR INT'L GOVERNANCE INNOVATION, Apr. 2018, at 1, 3 [hereinafter Contreras, *Evolving Patent Pledge Landscape*], https://www.cigionline.org/sites/default/files/documents/Paper%20no.166%20Cover_0.pdf [https://perma.cc/WUA2-25AE] (discussing evolution of Tesla pledge over time).

whether any deal in Paris was brokered by Mr. Gore,[6] the episode brings to the forefront the potential role that patents can play in fostering the development of technologies to mitigate global climate change.

In the area of climate change mitigation and other green/clean technology (green/clean tech), a variety of proposals to increase innovation and diffusion of technology have been made, many of them involving adjustments to the patent system.[7] Such proposals have encompassed strategies to *increase* the number of green/clean tech patents to encourage private sector investment in innovation and to *decrease* either the number or potency of such patents in an effort to reduce the costs of innovation globally. In the first category (enhancing patenting), proposals have been made to accelerate or "fast track" patent applications for green/clean tech inventions,[8] and to aggregate patents into an international licensing organization situated to tax greenhouse gas emitters.[9] In the category of decreasing the strength of, or increasing access to the technology covered by, green/clean tech patents, proposals have been made for: the compulsory licensing of green/clean tech patents by governments;[10] the exercise of

6. *See, e.g.*, Chris White, *Top Indian Official Refutes Claim that Al Gore Sealed India's Inclusion in Paris Deal*, DAILY CALLER (July 25, 2017, 4:17 PM), https://dailycaller.com/2017/07/25/top-indian-official-refutes-claim-that-al-gore-sealed-indias-inclusion-in-paris-deal/ [https://perma.cc/T3XP-2DVG]; Emily Atkin, *The Troubling Return of Al Gore*, NEW REPUBLIC (July 24, 2017), https://newrepublic.com/article/143966/troubling-return-al-gore-profile-inconvenient-sequel [https://perma.cc/UTM9-YK5N].

7. Some commentators are skeptical that patent-based incentive mechanisms will have a meaningful effect on the development and dissemination of new technologies to address climate change. *See, e.g.*, ERIC L. LANE, CLEAN TECH INTELLECTUAL PROPERTY: ECO-MARKS, GREEN PATENTS, AND GREEN INNOVATION 236–37 (2011) ("[T]ransfer and implementation of clean technologies is happening, again and again, despite what the debating parties may think or say. . . . Intellectual property protection did not prove a barrier to these agreements and transactions."); Ofer Tur-Sinai, *Patents and Climate Change: A Skeptic's View*, 48 ENVTL. L. 211, 222–25 (2018) (favoring incentive mechanisms such as prizes and subsidies).

8. *See* Anthony E. Chavez, *Exclusive Rights to Saving the Planet: The Patenting of Geoengineering Inventions*, 13 NW. J. TECH. & INTELL. PROP. 1, 31–32 (2015); Patrick Gattari, *The Role of Patent Law in Incentivizing Green Technology*, 11 NW. J. TECH. & INTELL. PROP. 41, 44 (2013); Antoine Dechezleprêtre, *Fast-Tracking Green Patent Applications: An Empirical Analysis*, INT'L CTR. TRADE & SUSTAINABLE DEV. (Feb. 2013), https://www.ictsd.org/sites/default/files/downloads/2013/02/fast-tracking-green-patent-applications-an-empirical-analysis.pdf [https://perma.cc/96V9-V73D] (describing fast-tracking programs around the world).

9. *See* John Vendenberg et al., *Using Patents to Curtail Climate Change: A Proposal*, LAW360 (Feb. 23, 2015, 10:18 AM), https://www.law360.com/amp/articles/622594.

10. *See, e.g.*, Chavez, *supra* note 8, at 21–27 (discussing benefits and practical difficulties of compulsory licensing approaches); Jerome Reichman et al., *Intellectual Property and Alternatives: Strategies for Green Innovation* 30–33 (Chatham House Energy, Env't and Dev. Programme Working Paper No. 08/03, 2008) ("[T]he primary defensive options for developing countries would reside in article 31 of the TRIPS Agreement, which

governmental march-in rights;[11] the acquisition of green/clean tech patents by a fund which would make them freely (or more broadly) available;[12] an exemption from patent infringement for noncommercial research and experimental use;[13] the statutory exclusion of some green/clean technologies from the scope of patent protection;[14] and constraints on the exclusive licensing of green/clean tech inventions.[15] At the extreme end of environmental activism, calls have been made to abolish patents entirely.[16] In this Article, we examine a private ordering approach to incentivizing the dissemination of green/clean technologies: the collective patent pledge, or commons.

Although patents give their owners the right to exclude others from practicing a patented technology or to charge them for the privilege of doing so,[17] an increasing number of firms across different industries have begun to make voluntary pledges intended to limit their ability to enforce their patents to the fullest

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allows compulsory licenses to be issued on patented inventions for almost any reason, subject to the payment of compensation and certain other technical prerequisites."). *But see* Charles R. McManis & Jorge L. Contreras, *Compulsory Licensing of Intellectual Property: A Viable Policy Lever for Promoting Access to Critical Technologies*?, *in* TRIPS AND DEVELOPING COUNTRIES: TOWARDS A NEW IP WORLD ORDER? 109, 112–13, 127–30 (Gustavo Ghidini et al. eds., 2014) (questioning advisability and effectiveness of compulsory licensing in clean/green tech area).

11. *See* Joshua D. Sarnoff, *The Patent System and Climate Change*, 16 VA. J.L. & TECH. 301, 354–56 (2011) (suggesting that governmental march-in criteria be clarified and expanded in this area).

12. *See* Matthew Rimmer, *The Paris Agreement: Intellectual Property, Technology Transfer, and Climate Change*, *in* INTELLECTUAL PROPERTY AND CLEAN ENERGY: THE PARIS AGREEMENT AND CLIMATE JUSTICE 33, 39–40 (Matthew Rimmer ed., 2018) (describing the Green Climate Fund); Chavez, *supra* note 8, at 32–35 (urging the U.S. government to facilitate formation of a "climate-engineering patent pool" that would grant licenses broadly at accessible rates).

13. *See* Jesse L. Reynolds et al., *Solar Climate Engineering and Intellectual Property: Toward a Research Commons*, 18 MINN. J.L. SCI. & TECH. 1, 45–46 (2017) (applying the historical exemption to patentability of natural phenomena to climate innovations); Sarnoff, *supra* note 11, at 344–48.

14. *See* Sarnoff, *supra* note 11, at 336–43 (proposing exclusion of basic R&D from patentability); Shobita Parthasarathy et al., *A Public Good? Geoengineering and Intellectual Property* 11–12 (Univ. of Mich. Gerald R. Ford Sch. of Pub. Pol'y Sci., Tech. & Pub. Pol'y Program, Working Paper No. 10-1, 2010) (recommending that geoengineering patents, especially those related to mechanisms to combat climate change, be narrow, if awarded at all).

15. *See* Sarnoff, *supra* note 11, at 352–54.

16. *See* Mark Read, *Al Gore's Convenient Infomercial*, INDYPENDENT, Sept. 2017, at 15 ("If we are to survive as a species, the legal, economic and cultural structures that privilege private ownership of intellectual property over the interests of the many must be challenged and fought at every turn. This must become a cornerstone of our fight for a more just and sustainable future. If we do not pull this system out by its roots, it is going to kill us all and our children.").

17. *See generally* 35 U.S.C. § 271 (2012).

degree.[18] Yet the pledging of patents, even to the extent that they will not be asserted against infringers, stops short of abandoning or contributing them to the public domain.[19] Thus, under a pledge model, also referred to as a patent commons, patent assets are retained by their owners, who continue to incur maintenance and other fees, but the use of such patents for traditional exclusionary purposes is significantly curtailed.[20]

Patent commons differ from other mechanisms used to share patents, including cross-licensing agreements and patent pools, in important ways. For example, in both cross-licensing agreements and patent pools, access to patents is granted only to participating companies, although in the case of patent pools, outsiders often can also access the pooled patents for a fee.[21] The main difference between these structures and further-reaching mechanisms, like the patent commons, therefore, is that the commons typically confers benefits on all third parties, regardless of their contribution to the commons and typically without a formal contract or payment.[22]

Patent pledges are made for a variety of reasons, including the promotion of broad product interoperability through common technical standards, the advocacy of new technology platforms, and the pursuit of social goals.[23] Over the past few decades, significant patent pledges have been made in areas such as open source software (e.g., IBM, Sun, Google and Red Hat (now owned by IBM) have each pledged that they will not assert hundreds of

18. Contreras, *Patent Pledges*, *supra* note 5, at 545–46.

19. Several large patent holders, including IBM, have a well-articulated strategy for abandoning unused patents. *See* Dennis Crouch, *IBM's Patent Abandonment Strategy*, PATENTLY-O (Mar. 1, 2012), https://patentlyo.com/patent/2012/03/ibms-patent-abandonment-strategy.html [https://perma.cc/9EL2-TEC5]; Bridget Diakun, *Inside the IBM Patent Factory*, INTELL. ASSET MGMT. (May 9, 2019), https://www.iam-media.com/patents/inside-ibm-patent-factory ("Although IBM invests heavily in building its portfolio, it actively abandons patents to streamline its holdings."). Other coordinated industry efforts have contributed substantial intellectual property assets to the public domain for self-interested purposes. *See, e.g.*, Jonathan M. Barnett, *Property as Process: How Innovation Markets Select Innovation Regimes*, 119 YALE L.J. 384, 434–37 (2009).

20. *Eco-Patent Commons: Joining or Submitting Additional Patents to the Commons*, WORLD BUS. COUNCIL FOR SUSTAINABLE DEV. [hereinafter *EcoPC Contributions*], http://www.otromundoesposible.net/wp-content/uploads/2012/07/EcoPatentGroundRules.pdf [https://perma.cc/E25F-P5K6] (last visited Sept. 12, 2019) (containing so-called "defensive suspension" provisions that allow pledging companies to deny royalty-free access to other companies that assert their patents against the pledging firm, suggesting that some patents are held for purely defensive purposes rather than as exclusionary rights).

21. *See* Anne Layne-Farrar & Josh Lerner, *To Join or Not To Join: Examining Patent Pool Participation and Rent Sharing Rules*, 29 INT'L J. INDUS. ORG. 294, 296 (2011).

22. *See* Contreras, *Patent Pledges*, *supra* note 5, at 546.

23. *See id.* at 572–74, 594; Contreras, *Evolving Patent Pledge Landscape*, *supra* note 5, at 4–5.

patents against open source software implementations); electric vehicles (in addition to Tesla Motors' famous pledge, Toyota has made a significant pledge of patents covering its hydrogen cell vehicles);[24] and biotechnology (e.g., Monsanto's pledge not to assert patents covering genetically modified seeds against farmers inadvertently growing them).[25] Over the years, some collective patent pledges, pledge communities and patent commons have achieved significant adoption in the marketplace, while others have not. For example, from its inception in 2014 through late 2017, Google's License on Transfer (LOT) network, in which patent holders commit not to transfer their patents to patent assertion entities (PAEs), attracted 180 members and more than 180,000 patents.[26] In contrast, the Defensive Patent License (DPL) network, which was launched in the same year with similar goals, has attracted few members.[27] The differences in take-up between these two pledge communities can be attributed to a variety of factors including internal governance mechanisms, commitment details, and evangelization.[28]

Unlike patent pledges that seek to foster technology or platform adoption, some pledges are made in support of philanthropic or corporate social responsibility (CSR) goals. For example, a number of patent pools seeking to improve access to lifesaving drugs in the developing world have emerged over the years. These pools, which include the Medicines Patent Pool (MPP) and The Pool for Open Innovation Against Neglected Tropical Diseases (NTD Pool), also include major pharmaceutical companies who participate largely in a philanthropic capacity (with concomitant public relations (PR) benefits).[29]

The EcoPC was an innovative not-for-profit initiative undertaken by a small group of industrial firms with the goal of pledging "green technology" patents for broad, royalty-free use in

24. *Toyota Opens the Door and Invites the Industry to the Hydrogen Future*, TOYOTA USA NEWSROOM (Jan. 5, 2015), https://pressroom.toyota.com/toyota-fuel-cell-patents-ces-2015/ [https://perma.cc/AX8N-JQB5]; *see also* Contreras, *Patent Pledges*, *supra* note 5, at 544 (discussing Toyota pledge).

25. *See generally* Contreras, *Evolving Patent Pledge Landscape*, *supra* note 5, at 1–2; Contreras, *Patent Pledges*, *supra* note 5, at 545.

26. *The LOT Network Community*, LOT NETWORK, http://lotnet.com/our-community/#member-list [https://perma.cc/Q9CJ-65Z8] (last visited Sept. 12, 2019).

27. *See* Contreras, *Evolving Patent Pledge Landscape*, *supra* note 5, at 5–6.

28. *See id.*

29. *See* Contreras, *Patent Pledges*, *supra* note 5, at 590–93 (describing philanthropic motivation for pledges); Michael Mattioli, *Communities of Innovation*, 106 NW. U. L. REV. 103, 121–27 (2012) (discussing MPP and NTD Pool).

addressing environmental challenges.[30] The thirteen EcoPC participants collectively pledged a total of 248 "green technology" patents (94 priority patents or distinct inventions) to the EcoPC between its formation in 2008 and its discontinuation in 2016.[31]

When created, the EcoPC had the ambitious stated objective of promoting the diffusion of green technologies to increase and accelerate their adoption and to encourage follow-on innovation. The theoretical mechanism to achieve this was simple: by suspending a patent owner's ability to assert a patent against any users of the patented technology, the technology—which had already been disclosed by the patent publication—would become available for royalty-free use by any interested party. In principle, this mechanism could address the well-known welfare cost associated with temporary market power granted by patents that likely slows the diffusion of patented technology.[32] A second possible benefit was that those building on the contributed technologies might find other (commercial) outputs of the contributing firm useful, or might add to a knowledge base from which the firm would benefit.[33]

Following its creation, the EcoPC attracted substantial attention in the scholarly literature,[34] the popular press,[35] and the

30. Dechezleprêtre, *supra* note 8.

31. *See infra* notes 41, 55 and accompanying text. Patents are territorial rights. That is, separate patents on the same invention have to be obtained in each jurisdiction where patent protection is desired. This means that there often exist multiple patents on the same invention, which are referred to as equivalents or members of a patent "family." The "priority" patent in such a family is the first patent filed within a given set of equivalents.

32. Bronwyn H. Hall & Christian Helmers, *The Role of Patent Protection in (Clean/Green) Technology Transfer* 5 (Nat'l Bureau of Econ. Research, Working Paper No. 16323, 2010).

33. Sharon Belenzon, *Knowledge Flow and Sequential Innovation: Implications for Technology Diffusion, R&D and Market Value* 5–7 (Ctr. for Econ. Performance, Working Paper No. 721, 2006), https://ssrn.com/abstract=893060 [https://perma.cc/R6Q6-N9GA]. Belenzon shows that it is profitable for a primary firm to cite a patent by a secondary firm if the instant patent cites the primary firm's patent. The market values the mutual citations and the benefits of the feedback loop spill over to the primary firm. *See id.*

34. *See, e.g.*, Andrew Boynton, *Eco-Patent Commons: A Donation Approach Encouraging Innovation Within the Patent System*, 35 WM. & MARY ENVTL. L. & POL'Y REV. 659, 679–82 (2011); Mattioli, *supra* note 29, at 142–43; Mark Van Hoorebeek & William Onzivu, *The Eco-Patent Commons and Environmental Technology Transfer: Implications for Efforts to Tackle Climate Change*, 2010 CARBON & CLIMATE L. REV. 13, 13.

35. *See, e.g.*, William M. Bulkeley, *Companies to Share Eco-Friendly Patents*, WALL ST. J., Jan. 14, 2008, at B2; Mary Tripsas, *Everybody in the Pool of Green Innovation*, N.Y. TIMES, Nov. 1, 2009, at BU5.

blogosphere.[36] Even environmental activist groups such as Greenpeace had good things to say about the project.[37]

But in addition to accolades, the EcoPC attracted some skepticism regarding its potential effectiveness. This skepticism focused, among other things, on whether a commons could offer sufficient incentives to attract valuable patent pledges and thereby achieve its ambitious goals.[38]

In contrast to other mechanisms designed to share patents, such as cross-licensing and patent pools, patent owners in the EcoPC maintained ownership of their patents (which is costly)[39] while making those patents freely accessible to third parties, including competitors. Some competitive safeguards were left in place, notably a defensive termination right in case a different patent was asserted against the pledger by a firm using the patented technology. For these reasons, it was not obvious what benefits the commons offered to participants beyond reputational enhancement. This, in turn, meant that participants could have had incentives to minimize their costs by pledging only patents with little commercial value and allowing them to lapse shortly after they were pledged.[40]

In an earlier study, Hall and Helmers studied the characteristics of the patents pledged to the EcoPC.[41] Their study confirmed that the pledged patents did claim environmentally friendly technologies. Moreover, pledged patents were of similar value to other patents in the pledging firm's portfolio, but of lower value than other patents in their class, using the usual patent value indicators (based on citations, family size, number of patent technology classes, etc.). The findings suggested that the EcoPC participants might have pledged patents with the potential to

36. *See, e.g.*, David Bollier, *New Eco-Patent Commons*, DAVID BOLLIER (Feb. 8, 2008, 12:00 AM), http://www.bollier.org/new-eco-patent-commons [https://perma.cc/L767-UENN] ("The idea, inspired by open source software and the Creative Commons, is to promote more eco-friendly manufacturing and waste-reduction processes. Bravo to IBM, Nokia, Sony and Pitney Bowes!").

37. *See, e.g.*, Bulkeley, *supra* note 35, at B2 (quoting John Coequyt, an energy policy specialist with the Washington office of Greenpeace, who praised the EcoPC as a potential "way to solve the [global warming] problem by voluntary action").

38. *See* Krishna Ravi Srinivas, *Sink or Swim: Eco-Patent Commons and the Transfer of Environmentally Sustainable Technologies*, BIORES TRADE & ENV'T REV., May 2008, at 14, 16.

39. The EcoPC participants were not, however, required to continue to pay maintenance fees on pledged patents. *See infra* Section IV.B (discussing lapse of patents for nonpayment of maintenance fees).

40. *See infra* notes 92–97 and accompanying discussion (examples of patents pledged).

41. Bronwyn H. Hall & Christian Helmers, *Innovation and Diffusion of Clean/Green Technology: Can Patent Commons Help?*, 66 J. ENVTL. ECON. & MGMT. 33 (2013).

diffuse environmentally friendly technologies that were possibly useful to other firms and researchers.

To study whether the EcoPC increased the diffusion of green technologies, Hall and Helmers looked for changes in forward citations to pledged patents following their addition to the commons. They constructed a set of control patents that matched the publication authorities, priority years, and technology classes of the EcoPC patents. They examined the pattern of citations by subsequent patent applications to the set of EcoPC patents and their controls over time, before and after contribution and found that the EcoPC patents tended to be cited *less* than the patents in the control group *before* contribution to the EcoPC. However, the results after contribution were inconclusive because most of the patents were contributed in late 2008 and there was little data post-pledge as citation data was available only through early 2012, leaving little more than three years of citation data post-pledge.

In this Article, we assess the effect of the EcoPC on technology diffusion and assess its impact more broadly, using several approaches. The first is a set of interviews with participants in the EcoPC and those responsible for it, described in Part III. These interviews provide helpful qualitative information that allows us to better understand the underlying causes of the EcoPC's failure to encourage the diffusion of pledged technologies. The second is an updated look at the data on the patents pledged to the EcoPC, described mainly in Part IV. With the passage of time, substantially more citation data has become available (through 2016 as opposed to early 2012 in Hall and Helmers' earlier study). This allows us to reexamine the data and provide a more definitive answer to the question of whether the commons had any effect on technology diffusion, at least as reflected in subsequent patenting. The fact that several new commons were created at the same time the EcoPC was discontinued in 2016,[42] also motivates us to revisit the viability of such patent commons more generally. Finally, we asked inventors of the patents that cited any of the EcoPC patents after they were pledged about the role that the pledge played in their decision to rely on an EcoPC patent as prior art.

To summarize our main findings: we do not find any evidence that the EcoPC increased the diffusion of pledged patents. Pledged patents were cited less than the matched control patents before they entered the commons, suggesting that they were already less valuable, and their pledge does not change this. Inventors of citing patents unanimously indicated that the pledge, i.e., royalty-free

42. *See infra* note 63.

access, did not affect their decision to rely on an EcoPC patent as prior art. In fact, none of the inventors that responded to our query were even aware that the cited patent was part of the EcoPC, and hence, royalty-free access played no role in their decision to rely on it as prior art. These results suggest that the commons had no effect on technology diffusion. Looking at the EcoPC priority patents, 82% had lapsed by July 2017 (26% expired, 18% were rejected or withdrawn, and 38% lapsed because of renewal fee nonpayment). Expired patents were not replaced by new patent pledges. This indicates that participating companies, in most cases, did not consider the benefits of the commons sufficiently large to maintain the patents in force. Our interviews with representatives of the EcoPC participants reveal several common critiques of the EcoPC's structure and operational processes that help explain our quantitative findings, particularly EcoPC's inability to provide information regarding the usage of contributed technologies.[43] Another major impediment to diffusion was the lack of information provided by pledging companies beyond the patent documents that could have helped potential users (especially in developing countries) see potential applications of the pledged technologies. Finally, no concerted effort was made to group or link patents in the commons to any particular technology. This lack of coordination may have limited synergies that could have been created through a more deliberate approach to the technologies covered by contributed patents.

This study both updates Hall and Helmers' previous study and fills gaps in our understanding of the functioning and performance of the EcoPC and patent commons more generally. Providing a more definitive answer to the question of diffusion and the functioning of the EcoPC more broadly is important for three reasons. First, it offers insight regarding the manner in which patent pledges can support the diffusion and implementation of (green) technologies around the world. Second, it can inform the design of other pledge communities both in the environmental space and other key technology areas, such as electric vehicles, software, biotechnology, and agriculture. Third, it informs us more generally about the viability of patent commons created by for-profit companies as a mechanism to share access to patented technology.

The remainder of this article is structured as follows. Part II describes the institutional design and history of the EcoPC. Part

43. This feature of the commons also limits our ability to study subsequent use of the pledged patents, which is why we chose to focus on publicly-available citations to these patents.

III summarizes the findings from our interviews of participants in the EcoPC. In Part IV we turn to a quantitative analysis of these patents and their citations and discuss the results of our inventor survey. Finally, in Part V we analyze our findings and assess their impact on the planning and design of future patent commons.

II. THE ECO-PATENT COMMONS: STRUCTURE AND DEVELOPMENT[44]

The concept of the EcoPC as a collective mechanism for permitting broad usage of patents covering environmental technologies was originally developed by IBM in the mid-2000s as one of several corporate initiatives directed toward environmental protection and sustainability.[45] Given IBM's well-known patent strength,[46] a program to promote environmental causes would capitalize on one of the company's principal assets. IBM had already made significant commitments to the sharing of patents and other intellectual property (IP) in the area of open source code software.[47] Accordingly, extending these initiatives to the environmental area was consistent with IBM's existing corporate culture.[48]

The idea behind the EcoPC was that industrial firms with large patent portfolios likely hold patents covering technologies

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44. The material in this part is derived both from the works cited and also from the interviews described in Part III, below. Additional information regarding the organization and history of the EcoPC can be found in Mattioli, *supra* note 29; *see also* Hall & Helmers, *supra* note 41; Bassem Awad, *Global Patent Pledges: A Collaborative Mechanism for Climate Change Technology*, CTR. FOR INT'L GOVERNANCE INNOVATION, Nov. 2015, at 1, 5–6, https://www.cigionline.org/sites/default/files/no.81.pdf [https://perma.cc/XV3K-QB6N].

45. *See infra* note 54.

46. According to U.S. Patent and Trademark Office statistics, IBM regularly receives more U.S. patent grants than any other company in the world—over 7,000 patents in 2015 alone. U.S. PATENT AND TRADEMARK OFFICE, PATENTING BY ORGANIZATIONS (UTILITY PATENTS) B1-1 (2015), https://www.uspto.gov/web/offices/ac/ido/oeip/taf/topo_15.pdf [https://perma.cc/4G8K-H4UR].

47. *See IBM Statement of Non-Assertion of Named Patents Against OSS*, IBM (Jan. 11, 2005), http://www.ibm.com/ibm/licensing/patents/pledgedpatents.pdf [https://perma.cc/73H7-VK8V]; *see also* Robert P. Merges, *A New Dynamism in the Public Domain*, 71 U. CHI. L. REV. 183, 188–94 (2004) (discussing IBM strategy related to patent non-assertion); Wen Wen et al., *Patent Commons, Thickets, and Open Source Software Entry by Start-Up Firms* (Nat'l Bureau of Econ. Research, Working Paper No. 19394, 2013), http://www.nber.org/papers/w19394.pdf [https://perma.cc/2F4M-MAHZ].

48. The EcoPC explicitly compared itself to the open source movement, noting in its promotional materials that, "[a]s has been demonstrated by the open source software community, the free sharing of knowledge can provide a fertile ground for new collaboration and innovation. Sharing environmental patents can help others become more eco-efficient and operate in a more environmentally sustainable manner—enabling technology innovation to meet social innovation." *About the Eco-Patent Commons*, ECO-PATENT COMMONS, http://ecopatentcommons.org/about-eco-patent-commons [http://web.archive.org/web/20161025065740/http://ecopatentcommons.org/about-eco-patent-commons].

with environmental applications, but because those technologies are not core to the firm's business, they are languishing unused.[49] If, however, the patents covering these technologies could be made freely available to users around the world, then a significant public service could be rendered at a minimal cost to the patent holder.

IBM publicly announced the concept for the EcoPC at its Global Innovation Outlook conference in 2006.[50] It then initiated discussions with other large firms with which it had existing business ties and which it believed might be sympathetic to a collective approach to making environmental technologies more broadly available. In January 2008, IBM announced the launch of the EcoPC together with Nokia, Pitney Bowes, and Sony.[51] A total of thirteen firms eventually joined the EcoPC as summarized in Table 1, below.

49. Numerous studies have shown that many patents in corporate portfolios go unused. *See, e.g.*, Paolo Giuri et al., *Inventors and Invention Processes in Europe: Results from the PatVal-EU Survey*, 36 RES. POL'Y 1107 (2007) (average 37% non-use by European patent holders); Salvatore Torrisi et al., *Used, Blocking and Sleeping Patents: Empirical Evidence from a Large-Scale Inventor Survey*, 45 RES. POL'Y 1374, 1379 (2016) ("Japan shows the largest share of unused patents (46%) compared to Europe (38%) and the U.S. (36%)"); Sadao Nagaoka & John P. Walsh, *Commercialization and Other Uses of Patents in Japan and the US: Major Findings from the RIETI-Georgia Tech Inventor Survey* (Research Inst. of Econ., Trade and Indus., Discussion Paper No. 09-E-011, 2009) (35% non-use by North American patent holders).

50. *See Corporations Go Public with Eco-Friendly Patents*, IBM NEWS ROOM (Jan. 14, 2008), https://www-03.ibm.com/press/us/en/pressrelease/23280.wss [https://perma.cc/92XX-WJWK].

51. *Id.*

Table 1: Firm Participation in the EcoPC[52]

Firm	Date Joining EcoPC	No. Patents Pledged*
IBM	Jan. 14, 2008	29
Nokia	Jan. 14, 2008	1
Pitney Bowes	Jan. 14, 2008	2
Sony	Jan. 14, 2008	4
Bosch	Sept. 8, 2008	24
DuPont**	Sept. 8, 2008	11
Xerox	Sept. 8, 2008	13
Taisei	Mar. 23, 2009	2
Ricoh	Mar. 23, 2009	1
Dow	Oct. 20, 2009	1
Fuji Xerox	Oct. 20, 2009	2
Hewlett-Packard	July 1, 2010	3
Hitachi**	July 25, 2011	1

* Priority patents (i.e., patent families).

** DuPont and Hitachi withdrew from the EcoPC in 2013, as of the transfer of EcoPC's management from WBCSD to ELI.

The stated mission of EcoPC was "to manage a collection of patents pledged for unencumbered use by companies and IP rights holders around the world to make it easier and faster to innovate and implement industrial processes that improve and protect the global environment."[53] Accordingly, patents eligible for inclusion in the EcoPC were required to belong to one of sixty enumerated International Patent Classification (IPC) codes relating to environmental or sustainability technology. Technologies sought by the EcoPC included energy conservation, pollution control, environmentally-friendly materials, water or materials use or reduction, and recyclability.[54] Two hundred forty-eight patents were pledged to the EcoPC, with the last such contribution occurring in 2011.[55]

To pledge a patent to the EcoPC, the owner was required to make an irrevocable covenant not to assert the patent—or "any

52. *E-PC All Pledged Patent*, ECO-PATENT COMMONS, http://ecopatentcommons.org/sites/default/files/docs/ecopatent-database.pdf [https://web.archive.org/web/20170304221125/http://ecopatentcommons.org/sites/default/files/docs/ecopatent-database.pdf].

53. *EcoPC Contributions*, *supra* note 20.

54. *The Eco-Patent Commons: A Leadership Opportunity for Global Business to Protect the Planet*, LEAN BUS. IR. (Jan. 2008) [hereinafter *EcoPC Brochure*], https://www.leanbusinessireland.ie/includes/documents/Eco-Patent%20Commons%20Brochure_011008%5b1%5d.pdf [https://perma.cc/V4VE-X7N8].

55. S*ee E-PC All Pledged Patent*, *supra* note 52.

worldwide counterparts"—against any infringing machine, manufacture process or composition of matter that "reduces/eliminates natural resource consumption, reduces/ eliminates waste generation or pollution, or otherwise provides environmental benefit(s)."[56] This being said, patent owners retained the (defensive termination) right to assert pledged patents against (a) any EcoPC participant that asserted any environmental patent against them, or (b) any non-EcoPC participant that asserted any patent against them.[57]

The initial administrator of the EcoPC was the World Business Council for Sustainable Development (WBCSD), a Geneva-based non-governmental organization focused on environmental and sustainability issues.[58] WBCSD's initial duties consisted primarily of hosting the EcoPC website and promoting EcoPC to other WBCSD members for purposes of recruitment. WBCSD publicized the EcoPC among its members and attracted several of the participants that joined following the EcoPC's formation.[59]

Participation in the EcoPC was open to all individuals and companies in the world, the only requirement for participation being the pledging of one or more patents according to the EcoPC's rules.[60] Neither membership in WBCSD nor any additional dues or charges were required for EcoPC participation. The EcoPC itself was characterized as an unincorporated, nonprofit association.[61]

In 2013, the administration of EcoPC was transferred from WBCSD to the Environmental Law Institute (ELI), a Washington, D.C.-based trade and advocacy organization.[62] This transition was apparently orchestrated by IBM, which had withdrawn as a member of WBCSD, thereby eliminating the primary driver of WBCSD's involvement. ELI, of which IBM was a significant

56. *EcoPC Contributions*, *supra* note 20.

57. *See EcoPC Brochure*, *supra* note 54 (describing this as a "defensive termination" provision).

58. *See Overview*, WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., https://www.wbcsd.org/Overview/About-us [https://perma.cc/CP5L-XKD5] (last visited Sept. 12, 2019); *EcoPC Brochure*, *supra* note 54.

59. *See supra* note 52 and Table 1.

60. Members of the EcoPC were required to complete a Membership Application/Pledge Form which bound them to comply with the EcoPC's Non-Assert Pledge, Ground Rules and Governance Structure. *See EcoPC Contributions*, *supra* note 20.

61. *See EcoPC Brochure*, *supra* note 54.

62. *See Royalty Free Environmental Patents*, ENVTL. L. INST. (Oct. 2013), http://www. eli.org/news/royalty-free-environmental-patents [https://perma.cc/9BSV-YSGF]. S*ee generally About the Environmental Law Institute*, ENVTL. L. INST., https://www.eli.org/about-environmental-law-institute [https://perma.cc/3FTX-SJMQ] (last visited Sept. 12, 2019).

member, hosted the EcoPC website from 2013 through 2016, but was not actively engaged in recruiting new participants. Two EcoPC members, Hitachi and DuPont, withdrew from the EcoPC at the time of this administrative shift. No new patents were contributed to the EcoPC after Hitachi's initial 2011 contribution. By 2016, very little activity was occurring at the EcoPC. Accordingly, in 2016, the EcoPC was formally discontinued.[63]

Though the EcoPC has been shut down, pursuant to the EcoPC Ground Rules and pledge terms, the "irrevocable" non-assertion pledge made with respect to each pledged patent will continue in accordance with its terms indefinitely.[64]

III. INTERVIEWS

This Part describes the results of a series of semi-structured interviews with representatives of participating companies, WBCSD and ELI.[65] Here we focus on the strengths and weaknesses of the EcoPC that were identified by interviewees in an attempt to inform our interpretation of our quantitative results on the diffusion of pledged technologies.

A. Methodology

We identified individuals employed by EcoPC corporate participants who had been personally involved with their employer's decision to join the EcoPC, its ongoing participation in the EcoPC, or both. Through online searches and informal inquiries, we were able to obtain valid and current contact details for representatives of nine of the thirteen EcoPC corporate participants. Seven of these individuals consented to be interviewed for this study (five by telephone and two by written

63. *Important Statement from the Board: Eco-Patent Commons to Cease Active Operations Effective May 18, 2016*, ECO-PATENT COMMONS, https://ecopatentcommons.org/ [https://web.archive.org/web/20170805131334/https://ecopatentcommons.org/]. Based on our interviews, *see infra* Part III, we understand that each EcoPC participant was consulted by IBM regarding the decision to wind-down the EcoPC. Apparently, there was no resistance to this course of action.

64. The Ground Rules make it clear that a patent owner's EcoPC pledge will survive that owner's withdrawal from the EcoPC. *See EcoPC Contributions*, *supra* note 20 ("Voluntary or involuntary withdrawal shall not affect the non-assert as to any approved pledged patent(s) – the non-assert survives and remains in force."). For example, Hitachi pledged a patent to the EcoPC in 2011, but withdrew from the EcoPC in 2013. This patent should remain pledged. *See* Contreras, *Patent Pledges*, *supra* note 5, at 598.

65. Interviews were conducted by Contreras pursuant to a determination of "no human subject research" by the University of Utah Institutional Review Board (Jun. 26, 2017, IRB 00102447). Interview subject information is held by Contreras.

correspondence).[66] In addition, we interviewed representatives of WBCSD and ELI who were directly involved in EcoPC activities.[67]

Each interview subject responded to questions relating to his or her employer's reasons for joining the EcoPC; how patents were selected for inclusion in the EcoPC; the company's ongoing engagement with the EcoPC; views regarding the discontinuation of the EcoPC; the company's overall satisfaction with the EcoPC; whether the company's goals in joining the EcoPC were achieved; and the relative strengths and weaknesses of the EcoPC structure. In addition, representatives of the WBCSD and ELI were asked questions relating to their operation and management of the EcoPC. These responses are summarized below.

The information gathered through these interviews is not necessarily representative of the views held by all member companies of the EcoPC as it is possible that interviewees selected into our sample based their responses on their subjective views of the performance of the EcoPC. That said, we obtained information from a relatively diverse sampling of company representatives (relative to the number of people involved in the project) across different geographical regions (companies based in the U.S., Europe, and Japan) and are therefore optimistic that these interviews offer relevant information in regard to a significant portion of the EcoPC participants' views regarding the organization.

B. General Responses

1. Joining EcoPC. Based on the sample of EcoPC participants interviewed, it appears that the primary drive to participate in the EcoPC came from management within each corporation's environmental, sustainability, or corporate social responsibility unit (for convenience, we refer to such business units as "environmental and social responsibility" or ESR). Although in most cases, the corporate legal or IP department was consulted, it was not the primary internal champion of participation in the EcoPC. In several cases, the decision to join the EcoPC was made by an executive or manager within the ESR

66. The authors have agreed not to disclose the identities of either the individuals interviewed or the EcoPC participant companies that they represented with the exception of IBM given its central role in forming and managing the EcoPC.

67. Interview scripts differed for individuals representing EcoPC participants versus administrators. Each interview lasted approximately thirty to sixty minutes. Responses were coded by the interviewer. No compensation was offered to interview subjects.

unit, with the legal department being involved only later (to help identify suitable patents for contribution).

Given the origin of EcoPC participation in corporate ESR units, it is not surprising that the rationales for joining the EcoPC were largely focused on improving global environmental conditions and sustainability. Several respondents mentioned a corporate culture of ESR, while a few expressed a desire to ensure that environmentally valuable technologies were made available in the developing world. Responses evoked themes of both environmental preservation/stewardship, as well as corporate social responsibility.

With respect to each of the corporate EcoPC participants other than IBM, the company was approached directly by a representative of either IBM or the WBCSD regarding participation in the EcoPC. In several cases, a personal relationship at the managerial or executive level facilitated the decision to participate.

One attractive feature that weighed in favor of joining the EcoPC was the lack of any financial commitment on the part of the participants. The only requirement for EcoPC participation was the identification and contribution of one or more patents. Several respondents indicated that their employers would probably not have joined the EcoPC had a membership fee been required. Probably due to the lack of a financial commitment, the corporate approval required for joining the EcoPC was, in some cases, handled at the level of the ESR unit. In at least one case, however, the company was required to obtain corporate approval at the board level.

It is interesting to note that none of the individuals that were interviewed identified a PR benefit as a principal justification for joining the EcoPC. While several interviewees acknowledged that positive PR associated with the EcoPC may have contributed to the decision to join, in particular at the executive level, the principal support for EcoPC participation within firms originated in, and was championed by, ESR business units with express goals directed to environmental sustainability. This observation runs counter to several prior analyses of the EcoPC, which speculated that PR benefits may have been significant motivators for firms to join.[68] Indeed, even the promotional materials created by the WBCSD to recruit additional EcoPC members emphasize these PR

68. *See* Contreras, *Patent Pledges*, *supra* note 5, at 591; Van Hoorebeek & Onzivu, *supra* note 34, at 18.

benefits.[69] Yet, it seems that PR may have played a relatively modest role in the decision of firms to join the EcoPC.

2. Selection of Patents. It was a starting premise of most firms that the patents pledged to the EcoPC would not be central to the firm's commercial interests. In fact, this feature was a "selling point" for membership in the commons: the patents that would be contributed were not expected to "represent an essential source of business advantage" for their owners.[70] As explained by one senior IBM executive, "[m]any patented environmental technologies are not strategic, so sharing maximizes the social benefit without sacrificing competitive advantage."[71] Thus, the patents contributed to the EcoPC were largely tangential to the primary business interests of the members. For example, IBM pledged a patent relating to recyclable cardboard packaging for electronic parts,[72] Nokia contributed a patent for recycling obsolete cellphones for use as calculators and personal digital assistants,[73] DuPont contributed a patented method for detecting pollution in soil, air or water by using a photoluminescent microorganism,[74] and Pitney Bowes contributed a patent claiming a design for electronic scales that are less likely to be damaged when they are overloaded[75] (a Pitney Bowes official explained that the patent related to the environment because "if you have a technology that extends the life of electronics, you keep it out of the waste stream").[76]

The manner in which specific patents were selected for contribution to the EcoPC varied among participants. IBM, reputedly the largest patent holder in the world, utilized a variety of internal searching and analysis tools to determine which of its patents were suitable candidates for contribution: both because they fit into the EcoPC's approved technology categories and were not actively being commercialized by IBM. Other firms used similarly sophisticated patent searching methodologies, including analysis of external citations to patent documents to determine whether patents had potential financial value. Some firms, even those with large patent portfolios, used less formal approaches. In

69. *See EcoPC Brochure*, *supra* note 54.

70. *See About the Eco Patent Commons*, *supra* note 48.

71. *See* Tripsas, *supra* note 35 (quoting Wayne Balta, Vice President of Corporate Environmental Affairs and Product Safety at IBM).

72. *See* U.S. Patent No. 6,997,323 (issued Feb. 14, 2006).

73. *See* U.S. Patent No. 7,251,458 (issued July 31, 2007).

74. *See* U.S. Patent No. 5,731,163 (issued Mar. 24, 1998).

75. *See* U.S. Patent No. 5,521,334 (issued May 28, 1996).

76. Bulkeley, *supra* note 35, at B2 (quoting Angelo Chaclas, Deputy General Counsel of Pitney Bowes).

one case, a patent was identified because a senior environmental manager at the company was named as an inventor on it. Another company asked its internal managers at the product division level to recommend patents for contribution. At one company, the majority of patents contributed originated within the ESR business unit, which championed EcoPC membership within the company. In all cases, EcoPC participants selected patents for contribution through internal mechanisms and did not engage external consultants or attorneys to assist with the search or selection process, which also helped keep the costs of participating in the EcoPC low.

3. Ongoing Engagement. All respondents indicated that a meaningful, though not overwhelming, amount of effort was required at the initiation of EcoPC participation, largely to identify relevant patents to contribute. After that initial determination was made, however, most firms (IBM being the notable exception) indicated that they engaged very little with the EcoPC. As noted above, there were occasional telephone conferences during which participants were updated regarding the EcoPC's activities, but after 2011, when the last new member joined, there was little in the way of updates. As noted above, none of the individuals that were interviewed recalled participating in any formal vote of EcoPC members, even when the decision to wind down the organization was made. This being said, most of the respondents did not object to this minimal level of involvement and did not feel the need to be involved to a greater degree.

4. Discontinuation. Each respondent was satisfied with the decision to wind down the EcoPC, indicating that the organization had run its course and provided comparatively little value by the time that it concluded. None of the respondents expressed disappointment or disagreement with the decision to discontinue the EcoPC. In fact, at least three respondents were unaware, at the time they were interviewed, that the EcoPC had been discontinued more than a year earlier, demonstrating that, at least in these cases, the EcoPC was a fairly insignificant activity for these companies.

C. Critiques of EcoPC

As noted above, most respondents viewed the EcoPC as a valuable demonstration of corporate willingness to collaborate to achieve environmental and sustainability goals. The PR benefits of EcoPC participation were also viewed as valuable by some companies. However, each of the respondents expressed

dissatisfaction with at least some aspects of the EcoPC which helps explain its failure to encourage the diffusion of the pledged technologies and ultimately the EcoPC's shutdown:

1. Membership and Recruitment. At its height in 2011, the EcoPC had thirteen corporate participants.[77] Though these firms were all major global enterprises with large patent portfolios, they still represented only a tiny fraction of the total potential membership in the organization. Particularly given that the EcoPC charged no membership fee, it was somewhat puzzling that so few firms joined. While WBCSD did appear to promote membership in the EcoPC, few of WBCSD's many members elected to join. Based on our discussions with EcoPC members, we believe that possible impediments to recruitment were: (a) the perceived difficulty and expense of identifying suitable patents for contribution; (b) a belief among potential members that they lacked patents that were suitable for contribution; and (c) an aversion to the idea of contributing potentially valuable patents to the EcoPC without compensation, a view generally held by legal and IP departments in contrast to corporate divisions focused on sustainability and corporate social responsibility.

2. No Tracking of Usage. All respondents observed that there was no effective way to determine whether the technologies covered by patents pledged to the EcoPC had been utilized.[78] As a result, it was difficult for them to draw conclusions regarding whether the EcoPC was worth the effort, and to determine whether the goals of improving environmental conditions and sustainability were being met. Moreover, without clear success metrics, it was difficult to justify devoting ongoing effort to the EcoPC to upper management at some companies. Several respondents indicated that the EcoPC made a conscious decision not to require users to register with the website or report back to the EcoPC, as such requirements would serve as barriers to use of the website.

Running somewhat counter to these comments, one interviewee noted that, in the early phase of the EcoPC, he/she received informal approaches from potential users seeking to understand the technology that had been made available through the EcoPC. This respondent indicated that during group calls with

77. *See supra* note 52 and Table 1.

78. This weakness was identified by commentators soon after the EcoPC's formation. *See* Jo Bowman, *The Eco-Patent Commons: Caring Through Sharing*, WIPO MAG., June 2009, at 11, 12, https://www.wipo.int/export/sites/www/wipo_magazine/en/pdf/2009/wipo_pub_121_2009_03.pdf [https://perma.cc/D2V5-P6EN].

EcoPC representatives, they would share information regarding how many calls of this nature they had received. However, such informal inquiries dropped off after the initial years of the EcoPC, which may suggest that the technologies were no longer perceived as useful.

WBCSD, at least initially, tracked hits to the EcoPC website and shared this information with the participants.[79] However, as noted above, identifying information about visitors was not collected, and it was not clear whether visitors were academics, students, attorneys, journalists or potential users of the technologies.

3. Notice of Available Technologies. It was noted by several interviewees that the cataloging of patents on the EcoPC website, which was organized by contributing company rather than technology area, was not particularly intuitive or informative. It required potential users to look up the relevant patents one by one in order to understand the technology being offered. Moreover, usually only a single patent family member was listed, requiring users to identify the remaining patent family members themselves. This procedure would have required both substantial effort on the part of potential users, as well as a high degree of familiarity with the format and terminology of patent documents.[80] As documented previously by Hall and Helmers, the website also listed a number of erroneous patent numbers, another potential source of frustration for users.[81] Taken together, these design shortfalls likely impeded the widespread usage of the EcoPC's resources.

4. Lack of Technology Transfer. Another issue raised by several respondents was that the EcoPC sought to promote the dissemination of green technologies through patents alone. Yet complex technologies often cannot be understood and implemented, especially by non-experts working in the developing world, merely through patent disclosures.[82] Some form of

79. Hall & Helmers, *supra* note 41, analyzed the data on web hits in an earlier study to find a highly skewed distribution of hits, only thirty-six patents received any hits. Nevertheless, the analysis also indicated a positive correlation between web hits and forward citations by other patents.

80. It is worth pointing out that this situation is changing rapidly at the present time, since Google patent search now includes the members of the patent family in its results. However, this feature was not available during most of the life of the EcoPC.

81. *See* Hall & Helmers, *supra* note 41, at 37.

82. *See, e.g.*, Colleen Chien, *Beyond Eureka: What Creators Want (Freedom, Credit, and Audiences) and How Intellectual Property Can Better Give It to Them (by Supporting, Sharing, Licensing, and Attribution)*, 114 U. MICH. L. REV. 1081, 1101–02 (reviewing

technology assistance or transfer is generally required to enable local users to take advantage of patented technologies, or even to realize that such technologies are available and applicable to local problems. This is especially the case with complex engineering and infrastructural technologies.[83] This issue was recognized by critics soon after the formation of the EcoPC,[84] and continued to be an issue throughout the life of the organization.

5. Emphasis on the Developing World. One of the motivating principles behind the EcoPC was that patents would be made freely available to users in the developing world,[85] much as the MPP and NTD Pool focused on the pressing health needs of underdeveloped countries.[86] However, many of the EcoPC contributed technologies had little relevance to industries in the developing world. For example, one of IBM's contributed patents related to a technique for cleaning semiconductor wafers using ozone gas to eliminate contaminants produced by chemical cleaning processes.[87] While this invention has a clear environmental valence, it would seemingly be useful only in a few industrialized countries that already have multi-billion dollar semiconductor fabrication plants.

In addition, the focus on the developing world belies a fundamental misunderstanding of the global patent system by some of the EcoPC planners. Patents prevent usage of a patented technology only in the countries where patents are issued. Most companies do not seek patent protection in the least-developed

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JESSICA SILBEY, THE EUREKA MYTH (2015)); Lisa Larrimore Ouellette, *Do Patents Disclose Useful Information?*, 25 HARV. J.L. & TECH. 545, 561 (2012).

83. *See* JOHN BARTON ET AL., INTEGRATING INTELLECTUAL PROPERTY RIGHTS AND DEVELOPMENT POLICY, REPORT OF THE UK COMMISSION ON INTELLECTUAL PROPERTY RIGHTS 138, 146, 150 (2002), http://www.iprcommission.org/papers/pdfs/final_report/ciprfullfinal.pdf [https://perma.cc/572W-7DM9]; McManis & Contreras, *supra* note 10, at 127 ("Unlike essential medicines, many clean technologies are not consumer products, but infrastructure improvements and capital projects such as wind farms, nuclear reactors, transmission grids and carbon recapture retrofitting of existing factories. While aspects of the design and operation of these facilities may be covered by patents, it is likely that technical skill and know-how will be more critical in implementing these technologies in the developing world.").

84. *See* Srinivas, *supra* note 38, at 17 ("Mere availability of one or two patents in a technology will not facilitate the transfer of [environmentally sustainable technologies] . . . . [C]ommercialisation [sic] involves training, learning to adopt and make efficient use of the technology. Therefore, while the availability of patents is necessary, it is not sufficient: access alone will not result in meaningful technology transfers or the optimum use of patents. There is thus a need to enable access to patents, but as part of a broader strategy of transfer of [technology].").

85. *See* Tripsas, *supra* note 35, at 5 ("[T]he hope is to encourage [the contributed technologies'] widespread adoption, particularly in the developing world.").

86. *See* Mattioli, *supra* note 29, at 121–27.

87. *See* U.S. Patent No. 6,178,973 (issued Jan. 30, 2001).

countries, either because protection is uncertain in those countries, or because their markets are underdeveloped and procuring patent protection is not viewed as cost effective.[88] Even in middle-income countries, multinationals tend to focus on pharmaceutical patenting and patenting in specific areas where the country in question is competitive.[89] Accordingly, many technologies that are patented in the developed world are not themselves patented in the developing world.[90] This general rule certainly applies to the patents contributed to the EcoPC, most of which have "family" members throughout the developed world (North America, Europe, Asia Pacific – see Table 4 below), but few if any patent family members in the developing world. Thus, organizations in the developing world *already* have the right to exploit many technologies disclosed in patents filed in the developed world. But they do not do so because, as discussed above, the utilization of even moderately complex technologies is not possible without significant training and technology transfer activity that cannot be accomplished through the grant of patent rights alone. In addition, technologies patented in the developed world may not be targeted to needs in the developing world without extensive further development.[91]

Ironically, the entities that would have most benefited from the non-assertion covenants made by EcoPC members were sophisticated firms in developed countries. At least one representative acknowledged this, noting that the most likely user of some of the company's contributed patents would be environmental service companies. Yet because the EcoPC made no concerted outreach to promote the availability of contributed technologies, even sophisticated firms were unlikely to find and use these technologies.

6. Shift in Corporate Priorities. Several interview respondents noted that corporate support for ESR initiatives

88. *See generally* AHN SANGHOON ET AL., INTELLECTUAL PROPERTY FOR ECONOMIC DEVELOPMENT 33–90 (2014) (explaining patenting strategies in developing countries).

89. *See generally* M.J. Abud et al., *The Use of Intellectual Property in Chile* (World Intell. Prop. Org., Working Paper No. 11, 2013); Bronwyn H. Hall & Christian Helmers, *The Impact of International Patent Systems: Evidence from Accession to the European Patent Convention* (Nat'l Bureau of Econ. Research, Working Paper No. 24207, 2018).

90. *See supra* note 88 and accompanying text.

91. The importance of technology transfer to the developing world in the area of green/cleantech has been emphasized before. *See, e.g.*, Joy Y. Xiang, *Addressing Climate Change: Domestic Innovation, International Aid and Collaboration*, 5 N.Y.U. J. INTELL. PROP. & ENT. L. 196, 212–22 (2016) (surveying international agreements and efforts toward transfer of environmental technologies to developing world); Reichman et al., *supra* note 10, at 25–37.

within their own companies had lagged during the life of the EcoPC, and that budgetary and resource constraints resulted in a de-emphasis of ESR initiatives. Some speculated that these industry-wide trends may have affected the willingness of new members to join the EcoPC. At least one interview subject identified his own company's declining commitment to sustainability during the period in which the EcoPC was in effect.

IV. QUANTITATIVE ANALYSIS

In this Part, we used the data on patents pledged to the EcoPC and their matched controls to analyze: (1) the legal status of EcoPC patents to gauge whether member companies considered continued ownership of their pledged patents as sufficiently important to incur the associated costs; and (2) the diffusion of the technologies protected by patents pledged to the EcoPC as measured by citations received from other patents.

A. Data

For the purpose of our quantitative analysis, we updated the database previously used by Hall and Helmers. This means that for comparison purposes, we restricted the set of patents to all patents pledged prior to July 2010, which excludes the four families pledged by Hewlett-Packard and Hitachi.[92] We also included the original control patents, which had been obtained by propensity score matching on priority year, IPC subclass, and publication authority.

Updating the data turned out to be somewhat complex, partly because the original data were drawn from a PATSTAT version with non-permanent identifiers, and partly because PATSTAT itself changes over time, with some data disappearing due to changes in the data at the contributing national or regional patent offices. In addition, the list of patents on the EcoPC website appears to have changed slightly, to some extent in response to our comments on the original list (incorrect numbers, etc.). We used the April 2017 PATSTAT version and identified a correspondence between the prior identifying numbers and the permanent (as of April 2011) identifiers using information on the application number and authority of the relevant patents. In a few cases, we were unable to find the application number-authority combination

92. In the case of the Hitachi patent, it is not clear that the patent was ever listed on EcoPC's public website. All versions of the EcoPC list of patents that we were able to locate using web archive tools were current only as of May 2011, prior to Hitachi's joining.

on the new version of PATSTAT. There were four such applications from the Japanese Patent Office (JPO), which apparently had been withdrawn and are no longer on its website.[93] We included them in our forward citation analysis as having zero cites, for completeness. In addition, twenty-four applications from the Australian Patent Office (APO) were reduced to twelve applications in the new PATSTAT file. Most of these problems affected the control patents rather than the Eco-patents.

The resulting dataset contains 698 applications rather than the original 711, with the distribution shown in Table 2.

Table 2: Dataset Construction

	Old (2011 data)	*New (2017 data)*
Number of applications	711	698
Controls	473	461
Eco-patents	238	237
Number of equivalence groups	184	184
Controls	94	94
Eco-patents	90	90
Number of citations	1872	4056
Controls	1205	2713
Eco-patents	667	1343

Note: Controls matched based on the publication authorities, priority years, and IPC classes of the EcoPC patents.

From Table 2, one can see that although the set of applications has changed slightly, we still have the same number of equivalent groups for the patents to be analyzed. It is also clear that the number of citations to both the EcoPC patents and controls has grown considerably, more than doubling in both cases.[94]

For our inventor survey, we extracted from PATSTAT the names of all inventors of all 329 patents that cited an EcoPC patent after the patent had been pledged to the commons. We then focused only on those patents where the citation to the EcoPC patent was not added by the examiner. This left us with 141

93. One problem with searching for JPO patents, especially the earlier ones, is that the numbering systems are quite complex and some numbers are apparently reused occasionally. *See Tips of Performing Japanese Patent Numbers Search*, PRIOR ART SEARCH & TRANSLATION, http://www.searchpriorart.com/search_tips/patent_no_search.htm [https://perma.cc/WBC2-MWGY] (last visited Sept. 12, 2019) (explaining the complexities of Japanese patent numbering). This problem leads to apparent errors on the Espacenet and Google patents websites. We also found that at least two of the equivalent patents we had identified for the controls became utility model patents when they were granted in Japan.

94. See *infra* Section IV.C for further analysis of the citations.

patents (43%). After undertaking some name-cleaning and harmonization, we obtained a total of 271 inventors. We then searched the web for their contact information. We were able to send our short questionnaire, which consisted of only three questions, to seventy-one (26%) inventors. We obtained responses from thirteen inventors, a response rate of 18%. However, only ten of these thirteen inventors agreed to answer our questionnaire. These ten inventors worked for four different EcoPC member companies: three inventors worked for Bosch, three for IBM, three for DuPont and one for Xerox. These are the four firms that contributed the largest number of patents to the commons.[95] We summarize the results briefly in Section IV.C, below.

B. Legal Status of the Pledged Patents

We began by looking at the legal status of the EcoPC pledged patents as of July 2017, summarized in Table 3. We collected these data from PATSTAT's legal status tables of April 2017 and supplemented the information using web searches. The WO (PCT) patents in our database will not have a post-grant legal status since they are granted on a national basis, and a few patent applications from the JPO could not be found, probably because the PATSTAT entries were for translations or they were utility model applications in Japan, even though they might have been patent applications elsewhere. There are fifteen such patents for which we did not have legal status, or legal status is meaningless. Of the remaining 221 patent applications, almost 20% of the ninety priority patents were still in force as of July 2017, but only 11% of all the equivalent patents. Of the twenty-seven patents still in force or pending, twelve are U.S. patents, six are Japanese, four are European Patent Office (EPO) or German, and the remainder are Chinese (one), Russian (two), Mexican (one), and Korean (one). Almost half the patents have expired for nonpayment of fees, although almost as many expired at the end of their terms.

95. *See supra* Table 2.

Table 3: Legal Status of Eco-Patents – July 2017

	All	*Priority*	*All*	*Priority*
pending	8	3	3.4%	3.3%
granted and in force	19	14	8.1%	15.6%
Total still active	**27**	**17**	**11.4%**	**18.9%**
nonpayment of fees	90	29	38.1%	32.2%
expired at term	61	30	25.8%	33.3%
rejected	18	7	7.6%	7.8%
withdrawn	24	7	10.2%	7.8%
Total not active	**193**	**73**	**81.8%**	**81.1%**
missing (from JPO)*	5	0	2.1%	0.0%
WO applications	11	0	4.7%	0.0%
Total	**236**	**90**		

*These appear to be translation entries or utility models.

In Figure 1 below, we show the distribution of patent lifetimes (approximated by the lapse (expiration or nonpayment) dates minus the application filing date).[96] In the case of patents still in force, we measured the lifetime to July 2017. The distribution is fairly flat for those patents that did not remain in force for their full terms. A substantial number of patents remained in force for either the full 20-year patent term or a significant portion of it. This suggests that in many cases, companies decided to pay renewal fees to keep the patents in force even after they had been pledged to the EcoPC.[97] For example JP4696713 "Wastewater treatment process"[98] by Fuji Xerox is still in force in four out of five jurisdictions in which it was filed. Other patents still in force include Sony's JP3876497 "Flocculating agent and a method for flocculation,"[99] which was granted in early 2007, and IBM's

96. Most jurisdictions now have a common patent term: 20 years from the filing date, but there are various exceptions, and older patents in our sample may have been issued under different rules. *See* WORLD INTELLECTUAL PROP. ORG., WORLD INTELLECTUAL PROPERTY INDICATORS 42 (2009), https://www.wipo.int/edocs/pubdocs/en/intproperty/941/wipo_pub_941.pdf [https://perma.cc/SV96-JRJL]. When we were able to obtain the actual expiration date, we used that (most cases).

97. Renewal fees usually increase over time. At the USPTO for example, large entities pay $1,600 to maintain a patent in force 3.5 years after grant and $7,400 11.5 years after grant. *See USPTO Fee Schedule*, U.S. PAT. & TRADEMARK OFF., https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule.html [https://perma.cc/PZ8E-RG8B] (last visited Sept. 12, 2019).

98. *See* JP Patent No. 4,696,713 (issued June 8, 2011); *see also Waste Water Treatment Method*, GOOGLE PAT., https://patents.google.com/patent/JP4696713B2/en [https://perma.cc/U6KA-BNNL] (last visited Sept. 12, 2019).

99. *See* JP Patent No. 3,876,497 (issued Jan. 31, 2007); *see also Flocculants and*

US6294028 "Mercury process gold ballbond removal apparatus,"[100] which was granted in 2001 and maintained in force throughout the entire lifetime of the EcoPC. However, there are also patents such as US5050676 "Apparatus for two phase vacuum extraction of soil contaminants"[101] owned by Xerox; the patent has five equivalents, four of which had expired before the patent was pledged, and the remaining patent expired at term less than a year and a half after the patent was pledged and no maintenance fees were payable during that time. This is an example of the pledge of a patent that most likely no longer had any value to the company.

Figure 1: Patent Lifetime Distribution for Eco-Patents

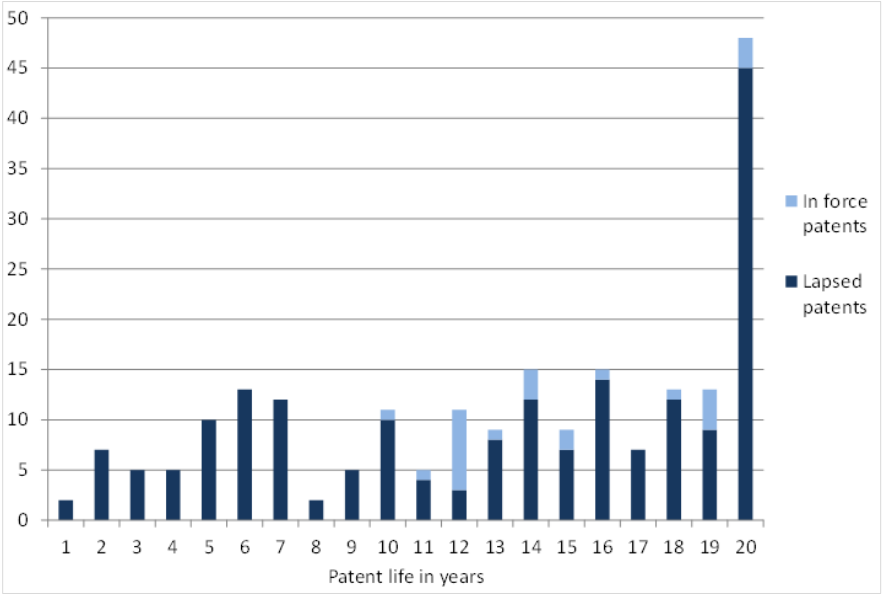

Figure 2 below breaks down the different reasons why patents lapsed. It shows that a significant number of patents have expired since 2007, the year before the EcoPC was launched. A few patents were rejected by the relevant patent offices or were withdrawn by applicants, but the majority lapsed due to nonpayment of renewal fees.

Coagulation Method Using the Same, GOOGLE PAT., https://patents.google.com/patent/JP3876497B2/en?oq=JP3876497 [https://perma.cc/YGT5-5W3T] (last visited Sept. 12, 2019).

100. *See* U.S. Patent No. 6,294,028 (issued Sept. 25, 2001).

101. *See* U.S. Patent No. 5,050,676 (issued Sept. 24, 1991).

Figure 2: Lapse Trends for Eco-Patents

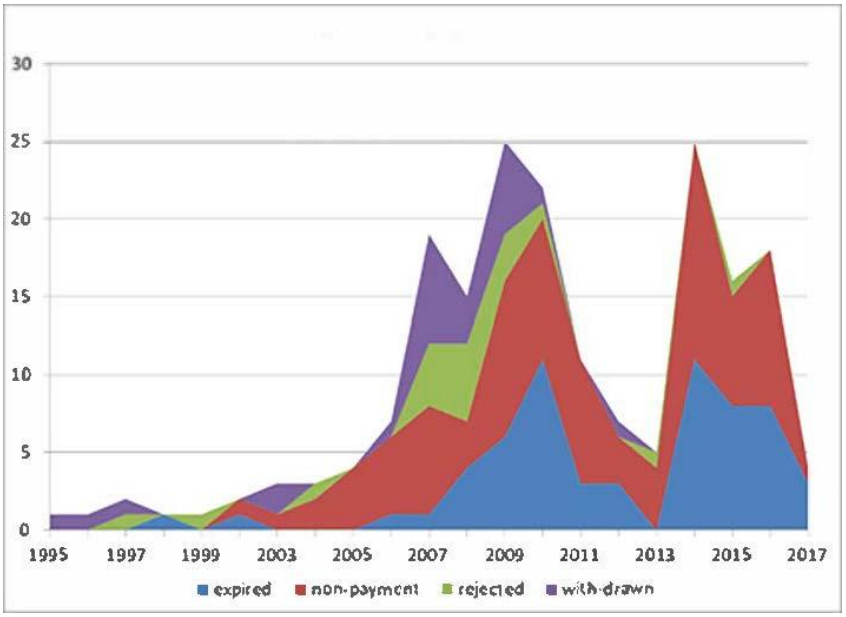

Table 4 below shows the geographic coverage of the EcoPC patents. Ninety percent of the priority patent applications were made to the four most important jurisdictions: the U.S., Germany, Japan, and the EPO, and these jurisdictions account for 80% of the patents overall. There is very little evidence that the patents in the commons ever covered less-developed countries. The only patents in middle-income countries are in Brazil (seven), Mexico (four), and Argentina (one), and there are none in low-income countries. The lack of patents in low-income areas shows that patents could not have been an obstacle to the use of technologies in less-developed countries.

Table 4: Application Authority Distribution

Authority		*Priorities*	*All*
USA	US	34	75
Germany	DE	20	45
Japan	JP	17	34
EPO	EP	10	34
South Korea	KR	2	7
China	CN	2	3
Austria	AT	1	4
Spain	ES	1	4
UK	GB	1	2
Norway	NO	1	2
Denmark	DK	1	1
Brazil	BR		7
Canada	CA		7
Mexico	MX		4
Australia	AU		2
Russia	RU		2
Argentina	AR		1
France	FR		1
Hong Kong	HK		1
Israel	IL		1
Total		**90**	**237**

C. Technology Diffusion and Follow-On Innovation

Next, we reexamine the question of technology diffusion by looking at the updated citation data. Hall and Helmers have previously suggested that pledged patents protect environmentally friendly technologies that could have the potential to be adopted for use by third parties.[102] To analyze any effect on diffusion, we adopt a difference-in-differences estimation, comparing the number of forward citations received by patents pledged to the EcoPC before and after they were pledged to citations received by the set of matched control patents that were not pledged to the EcoPC. Our estimation approach allows for different citation patterns between the set of EcoPC and control patents before the EcoPC patents were pledged. This accounts for concerns that pre-pledge citation behavior could be correlated with the decision to pledge a given patent to the EcoPC.

Table 5 below shows a comparison of standard patent characteristics between the set of patents pledged to the EcoPC and the matched (by priority year, IPC subclass, and publication

102. Hall & Helmers, *supra* note 41, at 34–35.

authority) control patents where we focus on the priority patents (Table A-1 in the Appendix shows the data for all equivalents). There are no statistically significant differences between the grant lag, the number of backward or non-patent literature references between the two sets of patents. Interestingly, EcoPC patents are more frequently granted. However, control patents have a larger family size and a larger number of claims, both of which are commonly used patent value indicators. This suggests that the EcoPC patents are potentially of less value than otherwise comparable patents. When we look at the number of forward citations received, the set of control patents accumulated a larger average number of citations than the pledged patents.

Table 5: Mean Patent Characteristics for eighty-nine Eco-Patents and ninety Control Patents

Variable	*Controls*	*Ecopatents*	*Difference (s.e.)*	*p-value*	*Kruskal-Wallis test**	*p-value*
Application year	1998.9	1998.8	-0.10 (0.68)	0.882	0.01	0.920
D (granted)	0.51	0.73	0.22 (0.07)	0.002	6.42	0.011
Grant lag in years**	3.93	3.74	-0.19 (0.55)	0.725	1.25	0.264
Family size	5.24	3.78	-1.47 (0.62)	0.018	4.54	0.033
Number of claims**	23.61	14.60	-9.01 (3.87)	0.023	2.88	0.090
Forward patent cites	22.67	13.22	-9.44 (4.04)	0.021	2.25	0.134
Backward patent cites	7.39	5.63	-1.76 (2.07)	0.397	1.74	0.187
Non-patent references	2.50	1.10	-1.40 (1.33)	0.294	0.02	0.903
Number of applicants	1.10	1.04	-0.06 (0.09)	0.553	0.02	0.899
Number of inventors**	2.70	3.00	0.30 (0.28)	0.294	2.12	0.145

Note: a few control observations (five in total) were lost due to missing data.
* The Kruskal-Wallis test is a rank test for the equality of the two populations.
** The mean is shown for non-missing observations only.

Table 6 below shows the share of EcoPC and control patents that receive any citations as well as the average number of citations received.[103] As indicated earlier, compared to Table 6 in Hall and Helmers prior work,[104] there are slightly fewer equivalents of our EcoPC patents and controls due to missing data and the consolidation at the APO. The share of patents that have citations has increased, becoming close to 90% for the equivalence groups, and the average citations per equivalence group has more than doubled. None of these results are unexpected, given the additional five years of data, as well as probable improvements in the PATSTAT coverage itself, but these results also highlight our much improved ability to assess the question of technology diffusion as a result of the EcoPC.

Table 6: Citation Counts for EcoPC Patents and Controls

	all patents	*equivalence group*	*all patents*	*equivalence group*	*all patents*
	Total patents		*Share with citations*		*Total citations*
Eco-patents	237	90	73.0%	85.6%	1343
Controls	461	94	57.1%	93.6%	2713

	*Average citations**		*Average citations***	
Eco-patents	10.5	17.4	5.7	14.9
Controls	13.2	30.8	5.9	28.9

Note: Citations are measured as all forward citations in the patent literature between the application date and April/May 2017, adjusted for citations by equivalent patents in other jurisdictions.

* Average over patents with nonzero citations.

** Average over all patents.

Table 7 and Figure 3 below show the key results of our new analysis. Poisson and negative binomial models of citations at the patent-level show that EcoPC patents are half as likely to be cited than the controls (an elasticity of 0.4–0.6), and even less likely after donation, although this last result is only marginally significant. These regressions control for both priority year and the citation lag using dummies.

It is well-known that the citation lag distribution for patents has a somewhat smooth structure, rising at first to a peak at three to five years and then declining slowly.[105] We therefore attempt to

103. *See infra* Table A-2 (showing a comparison of patent characteristics for patents with nonzero forward citations).

104. Hall & Helmers, *supra* note 41, at 45–46.

105. Bronwyn H. Hall et al., *The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools* 10 (Nat'l Bureau of Econ. Research, Working Paper No. 8498,

improve the precision of our estimates by imposing the Jaffe-Trajtenberg model of citation diffusion and decline[106] rather than using the citation lag dummies. This model, shown in the final three columns of Table 7 below, uses a parametric model for the citation lag that is given by the following equation:

$$c_{st} = b_0(1 + d_{eco}D_{eco} + d_{after}D_{after})f(t)\exp[-b_1(1 + b_{1e}D_{eco})s][1 - \exp(b_2(1 + b_{2e}D_{eco})s)] + e_{st}$$

Where "*t*" is the priority year of the cited patent, "*s*" is the citation lag, and "c_{st}" is the citation rate (the number of citations at that lag per sample patents available to be cited). *f(t)* is modeled as a set of priority year dummies. That is, the unit of observation is the average cites per patents with a given priority year, citation lag, and patent type (EcoPC patent before and after or control). Prior experience with this specification suggests that although it is an appealing model in that it captures both the initial increase in citation due to knowledge diffusion and the decline due to knowledge age, it is quite difficult to estimate successfully.[107] We do it in two ways: (1) nonlinear least squares with a dependent variable equal to average cites per patent; and (2) Poisson with a dependent variable equal to the total cites at the given lag to patents with a given priority year. In the latter case, we multiply the right-hand side of the model by the number of patents, so the models are equivalent. The results of the two estimation strategies are similar. Once we impose a model on the citation lag, the EcoPC patents are cited an average of 25% less than the controls, and there is no change after donation. The decay (obsolescence) and diffusion parameters are similar to those obtained by Hall and collaborators[108] for the U.S. patent data, with obsolescence increasing by about 5% per year, and diffusion about 50%. However, keep in mind that one reason the first is relatively low and the second relatively high is that there is a secular growth in citations that is not completely captured by the priority year dummies. That is, this model imposes a fixed citation lag structure on the data which is then allowed to be higher or lower, depending on priority year and EcoPC status. Because citations are often added by examiners rather than applicants,[109] we also report

2001); Adam Jaffe & Manuel Trajtenberg, *International Knowledge Flows: Evidence from Patent Citations* 5 (Nat'l Bureau of Econ. Research, Working Paper No. 6507, 1998).

106. Jaffe & Trajtenberg, *supra* note 105, at 19.

107. Hall et al., *supra* note 105, 29–33.

108. *Id.* at 33.

109. Note that for the purposes of analyzing diffusion, it is preferable to include

results in Appendix Table A-3 and Figure B-1 where we retain only citations made by applicants. That said, the results are very similar to the ones reported in Table 7 and Figure 3; there is no evidence of increased diffusion of patents after they were pledged to the EcoPC.

citations added by examiners because these citations also indicate that the citing patent builds on the cited prior art where this relationship was identified by examiners who are commonly experts in the relevant technology areas.

Table 7: Estimation of Citation Lag Models

Model	*Semi-parametric*						*Cites/patent*		*Jaffe-Trajtenberg*				
Dependent variable	*Cites*			*Cites*			*NLLS*		*Cites*				*Cites*
Method	*Poisson*		*Negative binomial*						*Poisson*				*Poisson*
EcoPC patent	-0.60	(0.11)	***	-0.42	(0.10)	***	-0.33	(0.09)	***	-0.22	(0.04)	***	-0.25	(0.05)	***
EcoPC patent after donation	-0.35	(0.21)		-0.33	(0.17)	*	-0.10	(0.18)		-0.01	(0.08)		0.01	(0.08)	
Decay parameter							0.07	(0.02)	***	0.04	(0.01)	***	0.05	(0.01)	***
Diffusion parameter							0.49	(0.21)	**	0.76	(0.19)	***	0.64	(0.21)	***
EcoPC decay													0.47	(0.38)	
Dispersion parameter				3.21	(0.17)	***									
Citation lag dummies		yes			yes			no			no			no	
Priority year dummies		yes			yes			yes			yes			yes	
Observations		3071			3071			518			518			518	
Log likelihood		-6,143.0			-3,745.2			-845.6			12,062.8			12,068.6	

Sample: 94 controls and 90 EcoPC patents with priority years between 1992 and 2005 and citing years between 1992 and 2016. The unit of observation in the first two columns is a priority patent-citing year and in the next three columns a priority year-citing year.
Standard errors are robust to heteroskedacity.
Significant at the 1%(***), 5%(**), and 10%(*) levels.

Figure 3: Cites per Patent by Citing Year (as of May 2017)

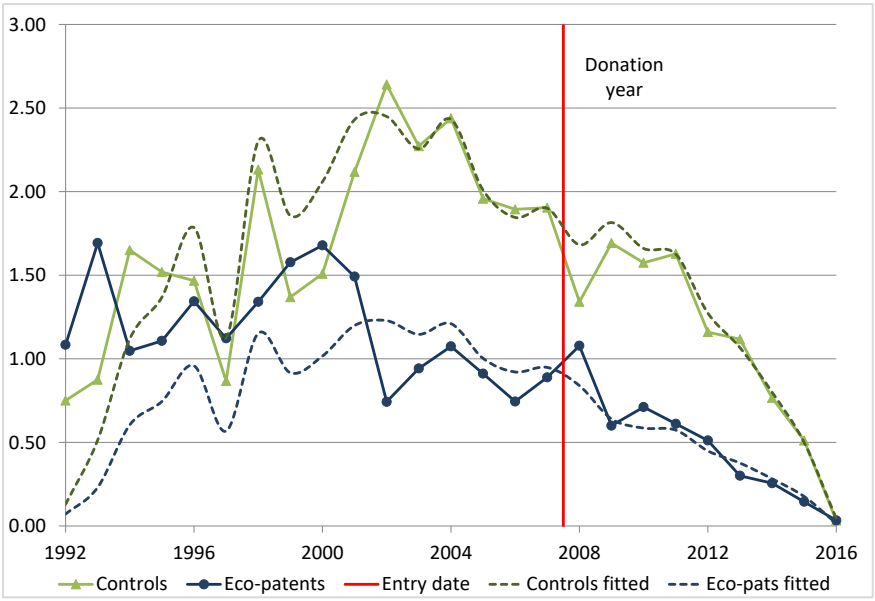

Table 7 and Figure 3 show that there is little change in aggregate citation differences between EcoPC patents and controls before and after being pledged to the commons, although EcoPC patents are cited less overall. It is important to remember, however, that because the pledging firms retain a defensive termination right, there may be continuing innovation building on these patents that does not result in new patent applications (and citations). That is, there are limits created on the enforcement of patent rights by the firms that use the technologies in these patents, which may reduce the benefits of subsequent patenting, and thus reduce citations to the pledged patent. This issue is related to a broader problem: our analysis of diffusion only looks for diffusion that leads to follow-on innovation that is patented. This excludes simple use of pledged patented technologies and even follow-on innovation if it does not lead to a patent filing. However, in the absence of any information on the use of pledged patents,[110] the forward citation analysis is the only way to quantitatively assess the impact of the patent pledge on diffusion.

It is also possible that the nature of the citation changes, in that the technology in the patents becomes more useful to individuals and nonprofit institutions given the absence of royalty requirements. We investigate this question by looking at the

110. *See supra* Part II.

source of the citations to the EcoPC patents and controls before and after donation. We divide the cites into five groupings according to their source: (1) self-citations from the firm that owns the pledged patent; (2) citations from other EcoPC participants; (3) citations from other firms; (4) citations from individual patentees; and (5) citations from non-profit institutions (universities, hospitals, public research organizations (PROs), and governments). We then define the before and after period for each grouping of citations according to the relation between the earliest priority date for the citing patent and the date the cited patent was donated to the commons. The results are shown in Table 8 below. In some cases, sample sizes are fairly small, but it does appear that self-citation falls relative to all the other categories, with the largest increases (by percentage) in citations by other EcoPC participants and non-profit institutions.

One issue that arises when counting the source of citations is that many patents have multiple applicants of different types. Given the nonrivalry of knowledge, which implies that one citer's use of the knowledge in a patent does not depend on use by another citer, it might be appropriate to simply count all the applicant-citations as citations as we did in the first panel of Table 8. Nevertheless, we also show a weighted version of the table in the second panel where the weights are proportional to the inverse of the number of applicants on the citing patent.[111] Although the distribution of cites changes dramatically when we weight, due to the tendency of individuals to share in applications, the qualitative conclusions with respect to the post-commons citing behavior are the same.

111. We removed individual inventor-applicants where there was also a firm applicant before computing the weights, on the grounds that these applicants usually are employed by the firm in question.

Table 8: Citations to the Eco-Patents by Citer Type

	Unweighted				*Weighted*			
Firm	*Before donation*	*After donation*	*Share before*	*Share after*	*Before donation*	*After donation*	*Share before*	*Share after*
Self-citation	141	24	9.9%	4.6%	127.1	12.9	12.3%	3.9%
Other eco-patent	11	13	0.8%	2.5%	8.0	7.3	0.8%	2.2%
Other firm	645	248	45.1%	47.1%	627.5	229.8	60.5%	68.8%
Individual	589	219	41.2%	41.6%	243.0	71.7	23.4%	21.5%
Institution	43	22	3.0%	4.2%	31.7	12.4	3.1%	3.7%
Total	**1429**	**526**			**1037.3**	**334.1**		

These totals are for cites to the contributed eco-patents only.
Weighted cites are weighted according to the number of applicants.

D. Inventor Awareness

As described in Section IV.A, in order to validate our quantitative results, we asked the inventors of patents that cited

an EcoPC patent after it was pledged: (a) whether they were aware of the citation (we exclude citations added by examiners); (b) if they were aware of the citation, whether they knew that the cited patent was part of the EcoPC; and (c) if they answered (a) and (b) affirmatively, whether the fact that the EcoPC patent was available for use royalty-free played any role in their decision to rely on it as prior art. As Section IV.A explains, we obtained valid responses from ten inventors; 50% indicated that they were aware of the citation, but none of them were aware that the cited patent was part of the EcoPC. While the sample of inventors is obviously very small, it nevertheless confirms our quantitative results: the pledge of a patent to the EcoPC was ineffective in spurring the diffusion of the patented invention. In fact, the responses from the inventors also confirm the results of our interviews with company representatives as they suggest that inventors were unaware of the EcoPC even when they relied on patents that were part of the EcoPC as prior art.

V. ASSESSMENT AND ANALYSIS

The results of our analysis suggest fairly strongly that the technologies covered by the contributed patents did not in fact attract significant interest by third parties, even before contribution to the commons. As a result, pledging these patents to the commons did not affect the interest of third parties in their underlying technologies and hence the commons did not promote their use and diffusion.

There is a growing literature concerning the factors that motivate patent holders to join patent pooling arrangements and seeking to understand why some patent holders elect not to join such pools.[112] The potential for monetary gain, which is central to many pooling decisions, is not a factor with respect to philanthropic and CSR-oriented pools such as EcoPC. Also, unlike the MPP and the NTD Pool, the EcoPC lacked significant governmental support and incentives,[113] perhaps making its path more challenging from the outset.

One of the reasons for the EcoPC's lack of effectiveness is likely the fact that it was conceived and implemented by the suppliers of technology as a volunteer effort without consulting the

112. *See* Layne-Farrar & Lerner, *supra* note 21, at 294–95; Michael Mattioli, *Patent Pool Outsiders*, 33 BERKELEY TECH. L.J. 225, 240 (2018).

113. *See* Mattioli, *supra* note 29, at 125–27 (describing governmental support and incentives in connection with MPP and NTD Pool).

demand side (potential users of these patents/technologies).[114] As such, the EcoPC was constructed in such a way that it was not easy for potential users to understand how the available technologies could be used. It simply offered a passive website with patent listings, rather than suggestions on how these technologies could be utilized, either separately or together.[115] Our results suggest that effective technology diffusion requires more than patent non-assertion, especially in the developing world. As discussed above, technical assistance and technology/know-how transfer are essential for implementing environmental technologies to an even greater degree than for software or pharma, and patent disclosures alone are seldom sufficient to enable someone to implement a technology effectively.[116]

Likewise, there was little or no coordination among EcoPC contributors regarding the technologies covered by the patents they were pledging. As previously discussed by Hall and Helmers,[117] the pledged patents appeared largely to protect different technologies. Hence, the implementation of a given technology might not have been possible using only pledged patents (i.e., any of the covered technologies could require the use of additional patents not contributed to the commons). As a result, synergies that could have emerged from the contribution of multiple patents covering selected technologies did not emerge.

Related to the previous point, the EcoPC was organized as a volunteer effort. Members paid no fees, and the WBCSD and ELI managed the organization largely as an accommodation to IBM. Without payment, ancillary value-added services are unlikely to be provided. This being said, some interviewees stated that their companies would not have joined EcoPC had they been required to pay membership fees. So, there is a clear trade-off, or perhaps a

114. A different approach has been attempted by WIPO Green, an online technology exchange platform that allows both potential technology users and suppliers to specify their needs and to find suitable transaction partners. *See WIPO GREEN – The Marketplace for Sustainable Technology*, WIPO, https://www3.wipo.int/wipogreen/en/ [https://perma.cc/5E8E-X22P] (last visited Sept. 12, 2019). Though WIPO Green has been operational since 2013, it is not clear that any substantial number of transactions are being effected using the platform, and several improvements have been suggested by commentators. *See* Joy Y. Xiang, *IPR Management in International Cleantech Cooperation*, 32 GEO. ENVTL. L. REV. 48–50 (forthcoming 2019).

115. A similarly unsuccessful supply-side model for patents can be found in the IPXI Exchange, an attempt to offer unitized licenses of pooled patents essential to certain industry standards. Like the EcoPC, IPXI failed to achieve significant take-up and eventually discontinued its operations. *See* Jorge L. Contreras, *FRAND Market Failure: IPXI's Standards-Essential Patent License Exchange*, 15 CHI.-KENT J. INTELL. PROP. 419, 432–39 (2016).

116. *See supra* notes 82–83.

117. Hall & Helmers, *supra* note 41, at 34–36.

need for public support or a tax incentive if an activity such as EcoPC is viewed as socially desirable. This also means that the ability to distribute the fixed costs associated with managing such an institution favors an approach that brings together a larger number of participating companies than the EcoPC.

Low membership can be attributed, in part, to the cost of the internal patent analysis that was required to contribute. Several of the original EcoPC participants were large, sophisticated organizations with internal patent analytical resources and a clear understanding of which patents would, and would not, advance corporate goals. Other firms may not have wanted to risk giving away a patent that could have potential value. Likewise, the internal effort of identifying these patents, without a clear payoff, may not have been viewed as worth the effort by overworked patent counsel.

Perhaps the most cogent critique of the EcoPC was its failure to track patent utilization. Without knowledge of how/whether patents were being utilized, companies could not justify expending further effort on the activity. Moreover, even the PR benefit of belonging to the EcoPC waned after the initial contributions, given that there were no 'success stories' to promote. More generally, the lack of information on usage meant that it was very difficult to gauge the success of the initiative and to make adjustments to its structure and management to improve its performance. Finally, the lack of demonstrable results from the project eroded the potential PR benefits that member firms may have hoped to achieve from participation in the EcoPC.

The lack of usage tracking underscores another weakness of the EcoPC, especially when compared to more successful pledge communities: the lack of dedicated administrative and managerial resources devoted to expanding and promoting the commons. While EcoPC was housed within well-established organizations such as WBCSD and ELI, these organizations received no additional compensation for managing the EcoPC and appear to have taken on this role as an accommodation to a significant member (IBM). Most trade associations have dedicated personnel for membership development, and enrolling members takes significant time and effort. Without these resources, it is not surprising that the EcoPC was unable to recruit a larger body of members nor that WBCSD and ELI spent few additional funds for EcoPC recruitment. As the example of DPL has shown,[118] the lack of dedicated managerial and promotional resources can contribute

118. Contreras, *Evolving Patent Pledge Landscape*, *supra* note 5, at 567–68.

to the failure of a pledge community to gain significant traction in the marketplace.

These difficulties and potential missteps in implementing the EcoPC almost certainly contributed to its demise, but they may not have been the only reasons that the EcoPC failed. Mattioli, writing near the peak of the EcoPC's activity, observed the diffuse and overly broad nature of the EcoPC's scope: reducing environmental harm.[119] This broad remit, in contrast to the goals of the narrowly focused MPP and NTD Pool, could have made it more difficult for potential licensees to conceptualize solutions to particular environmental problems using the tools offered by the EcoPC.

More generally, however, the EcoPC may have been a victim of changing corporate priorities in the global business environment. When IBM introduced the idea of the EcoPC to other large corporations in 2006, corporate sustainability had recently gone mainstream.[120] Many large corporations were experimenting with sustainability strategies and campaigns. The global economic recession that followed, however, served to constrain the social programs promoted by firms, including sustainability programs.[121] One of the ways in which ESR programs may have been "trimmed" during hard economic times was by emphasizing those programmatic components that would appeal specifically to consumers and de-emphasizing others.[122] The EcoPC, which was, almost by definition, tangential to the principal product markets in which its participants operated, may have had little direct impact on participants' customer relations. As such, attention to initiatives such as the EcoPC may have waned over the years of the global economic downturn, until the project finally withered entirely in 2016. This possibility is corroborated by the fact that at least half of the corporate EcoPC representatives whom we interviewed were retired at the time of our interview. The EcoPC and the ideals that it embodied may have been the product of a prior generation of corporate managers. If this is the case, then new commons efforts in the environmental space will need to develop strategies to rekindle corporate interest in ESR and green-technology solutions.

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119. Mattioli, *supra* note 29, at 155.

120. *See Just Good Business: A Special Report on Corporate Social Responsibility*, ECONOMIST (Jan. 19, 2008), https://www.economist.com/special-report/2008/01/19/just-good-business [https://perma.cc/Y9KH-NXFH] (interviewing Daniel Franklin).

121. *See* Michael L. Barnett et al., *Sustainability Strategy in Constrained Economic Times*, 48 LONG RANGE PLANNING 63, 64 (2015).

122. *Id.* at 66.

VI. CONCLUSION

The EcoPC represented a novel and ambitious cooperative activity by leading international firms to improve environmental sustainability through the contribution of under-utilized, non-core patents to a publicly-accessible pool. Though the participants in the EcoPC represented some of the largest and most influential patent holders in the world, our results demonstrate that the effort achieved only modest results and contributed little to technology diffusion. There are numerous reasons hypothesized for the failure of the EcoPC, ranging from defects in implementation, reporting and management, to a general shift away from corporate environmental and sustainability programs lacking direct customer benefits. Future initiatives seeking to make green technologies more widely available should consider the lessons learned from the EcoPC. There are clear trade-offs between costs and benefits that organizers of future efforts should consider.

The experience of the EcoPC, even though it did not realize its ambitious goals, has helped to advance our understanding of how patent commons can work and fail to work. As such, the EcoPC has made an undeniable contribution to the study of patent commons and pledges. The failure of the EcoPC to achieve significant technology diffusion and to attract significant corporate participation should not be viewed as a failure of the patent commons model itself. Instead, this worthwhile effort should be viewed as an invitation to experiment further with, and to improve upon, the patent commons model both in the area of green technologies and beyond.

APPENDIX A: ADDITIONAL TABLES

Table A-1: Mean Patent Characteristics for 236 Eco-Patents and 454 Control Patents

Variable	*Controls*	*Ecopatents*	*Difference (s.e.)*	*p-value*	*Kruskal-Wallis test**	*p-value*
Application year	1998.9	1997.8	-1.02 (0.39)	0.009	5.65	0.017
D (granted)	0.51	0.68	0.17 (0.04)	0.000	13.30	0.000
Grant lag in years**	4.63	4.14	-0.49 (0.30)	0.103	4.32	0.038
Family size	8.83	5.96	-2.87 (0.40)	0.000	43.19	0.000
Number of claims**	23.05	14.90	-8.15 (2.41)	0.000	9.63	0.000
Forward patent cites	27.24	15.92	-11.32 (2.28)	0.000	17.28	0.000
Backward patent cites	5.96	4.31	-1.65 (1.19)	0.167	8.49	0.004
Non-patent references	1.32	0.66	-0.66 (0.44)	0.136	0.10	0.758
Number of applicants	1.13	1.11	-0.02 (0.07)	0.765	0.18	0.673
Number of inventors**	2.83	2.91	0.07 (0.17)	0.675	3.61	0.057

* The Kruskal-Wallis test is a rank test for the equality of the two populations.
** The mean is shown for non-missing observations only.

Table A-2: Patents with Nonzero Forward Cites Only (437 Controls; 218 Eco-Patents)

Variable	*Controls*	*Ecopatents*	*Difference (s.e.)*	*p-value*	*Kruskal-Wallis test**	*p-value*
Application year	1998.7	1997.6	-1.14 (0.40)	0.004	7.13	0.008
D (granted)	0.51	0.70	0.19 (0.04)	0.000	15.23	0.000
Grant lag in years**	4.60	4.14	-0.46 (0.31)	0.131	3.29	0.070
Family size	9.03	6.26	-2.78 (0.41)	0.000	37.56	0.000
Number of claims**	23.23	15.11	-8.11 (2.45)	0.001	9.17	0.003
Forward patent cites	28.30	17.23	-11.07 (0.38)	0.000	13.05	0.000
Backward patent cites	6.11	4.57	-1.53 (1.26)	0.223	9.23	0.002
Non-patent references	1.36	0.70	-0.66 (0.47)	0.161	0.19	0.665
Number of applicants	1.12	1.11	-0.01 (0.07)	0.844	0.21	0.649
Number of inventors**	2.82	2.97	0.14 (0.18)	0.425	6.36	0.012

* The Kruskal-Wallis test is a rank test for the equality of the two populations.
** The mean is shown for non-missing observations only.

Table A-3: Applicant Cites Only

Model	*Semi-parametric*						*Cites/patent*			*Jaffe-Trajtenberg*			*Cites*
Dependent variable	*Cites*			*Cites*			*NLLS*			*Cites*			*Poisson*
Method	*Poisson*			*Negative binomial*						*Poisson*			
EcoPC patent	-0.87	(0.15)	***	-0.65	(0.13)	***	-0.65	(0.05)	***	-0.45	(0.08)	***	NOT
EcoPC patent after donation	-0.64	(0.29)	**	-0.51	(0.22)	**	–			–			IDENTIFIED
Decay parameter							0.05	(0.68)		0.09	(0.02)	***	
Diffusion parameter							0.13	(0.28)		0.10	(0.01)	***	
EcoPC decay													
Dispersion parameter				4.47	(0.35)	***							
Citation lag dummies	yes			yes			no			no			no
Priority year dummies	yes			yes			yes			yes			yes
Observations	3046			3046			512			512			512
Log likelihood	-3,422.0			-2,212.4			-588.6			3,566.6			

Sample: 94 controls and 90 EcoPC patents with priority years between 1992 and 2005 and citing years between 1994 and 2016. The unit of observation in the first two columns is a priority patent-citing year and in the next three columns a priority year-citing year.
Standard errors are robust to heteroskedacity.
Significant at the 1%(***), 5%(**), and 10%(*) levels.

APPENDIX B: ADDITIONAL FIGURE

Figure B-1: Applicant Cites per Patent by Citing Year (as of May 2017)