PRELIMINARY AND INCOMPLETE DRAFT

Innovation in Clean/Green Technology: Can Patent Commons Help?[1]

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Abstract

This paper explores the characteristics of 96 patents contributed by major multinational innovators to the "Eco-Patent Commons", which provides royalty-free access to third parties to patented climate change related innovations. By comparing the pledged patents to other patents in the same technologies or held by the same multinationals, we investigate the motives of the contributing firms as well as the potential for such commons to encourage innovation and diffusion of climate change related technologies. This study, therefore, indirectly provides evidence on the role of patents in the development and diffusion of green technologies. More generally, the paper sheds light on the performance of hybrid forms of knowledge management that combine open innovation and patenting.

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1. Introduction

Numerous well-known economists have called for policies to encourage both public and private investment in technologies designed to mitigate climate change (Mowery et al. 2010; David et al. 2009; Krugman 2009; Arrow et al. 2008). As Nordhaus (2009), among others, points out, policy in this area confronts a double externality problem: the first is private underinvestment in R&D due to partial lack of appropriability and imperfections in the financial markets and the second is the fact that climate change mitigation and reduction in greenhouse gases is a classical public good, and one with a substantial international component. That is, the benefits of climate change mitigation flow largely to those who do not bear the costs. Hall and Helmers (2010) argue that the existence of the second externality can impact the desirability of policies designed to deal with the first externality, shifting policy makers' preferences towards subsidies and away from intellectual property protection.

To make this argument more explicit, consider the usual policies designed to close the gap between the private and social returns to an activity. These are subsidizing (or issuing tax credits for) the activity, regulating the activity (mandating its performance or controlling the price of inputs), and internalizing the externality by granting property rights that allow some appropriation of the social benefits. In the case of R&D investment, the first approach has been widely used in the past for research directed towards national needs (Mowery 2010), for corporate R&D via tax credits, and for small and medium-sized enterprises (SMEs) that face credit constraints. Although the second approach has been used much less (and is probably less suitable for R&D activities due to their uncertainty and the difficulty of such micro-management), examples are the mandate of the State of California for sales of electric-powered automobiles (*reference needed*) and the U.S. federal government stimulus package, which mandates the diffusion of electronic medical records and their effective use (*reference needed*).

The most widely available policy designed to encourage private R&D investment in most countries is the intellectual property system. However, in the case of climate change mitigation (as in the case of R&D directed toward other national needs), allowing firms to appropriate social benefits via their market power and pricing behavior has the drawback that without further policy design, it will tend to inhibit the diffusion of the technologies whose creation it encourages. In addition to the welfare cost of limitied diffusion, IP protection also has potential negative consequences for subsequent innovation that builds on the protected technologies. Given the environmental externality, such diffusion and follow-on innovation is highly desirable. This has triggered an active debate on the role and usefulness of IPRs in the generation of climate change related innovation and its diffusion.[4]

[4] For a review of the relevant literature see Hall and Helmers (2010).

The existing evidence suggests that the IP system, specifically the patent system, may not be the optimal policy to encourage R&D in this area.

A number of large multinational firms such as Sony, IBM, Nokia, etc., appear to have recognized the problem with patents in the area of climate change related technologies and as a response, have created an "Eco-Patent Commons" (henceforth *EcoPC*) together with the World Business Council for Sustainable Development (http://www.wbcsd.org/). Firms pledging patents to this commons are required to sign a non-assertion pledge which allows third parties royalty-free access to the protected technologies. The official purpose of this private initiative is described on the EcoPC website as the following:

- To provide an avenue by which innovations and solutions may be easily shared to accelerate and facilitate implementation to protect the environment and perhaps lead to further innovation.
- To promote and encourage cooperation and collaboration between businesses that pledge patents and potential users to foster further joint innovations and the advancement and development of solutions that benefit the environment.

Obviously, one can imagine an additional purpose: to improve the reputation and public relations of the participating firms at relatively low cost, possibly by contributing patents on inventions of little value. Alternatively, the patents contributed could be those on inventions that need development effort that the firms in question are not willing to undertake. To date, there are 12 participating firms, and 96 patents have been contributed to the commons.[5] Relative to the size of these firms' patent portfolios, this is a small number; however, it could be large given the small share of directly climate-change related patents in total patenting.[6]

The question that we ask is whether the EcoPC initiative achieves its ambitious official objectives. In order to provide an answer to this broad question, we answer a range of intermediate questions: are the patented technologies indeed climate-change related? Are the patents that protect these technologies valuable? Will royalty-free access to the EcoPC patents lead to more diffusion of the protected technologies and the generation of sequential innovations than otherwise? Or is it a dead end, where lack of patent protection will nip potential innovation in the bud due to a perceived lack of available financial

[5] The figure excludes pledged equivalents. The firms that have contributed to date are Bosch, Dow, DuPont, Fuji-Xerox, IBM, Mannesmann, Nokia, Pitney Bowes, Ricoh, Sony, Taisei and Xerox. Note that the patent owned by Mannesmann was absorbed and pledged by Bosch, but we nevertheless treat Mannesmann as a separate entity in our analysis. The EcoPC announced on July 1 2010 that Hewlett Packard (HP) has joined the commons. Yet, we omit HP in our analysis as our data predates HP's entry into the commons.

[6] In fact, the 96 unique priorities accounted for by these patents are 0.02 percent of the priorities claimed by these firms between 1989 and 2005. The share ranges from 0.12 percent for DuPont to negligible for Ricoh, Sony, Nokia, and FujiXerox.

returns? Given the short amount of time the EcoPC has been in place, some of the answers will be of tentative nature; we nevertheless believe that the insights obtained from our analysis shed light on the potential of the commons to address the potential problem of patent protection with regard to the diffusion of patented climate change related technologies.

The question of whether the EcoPC scheme achieves its objectives is directly linked to firms' underlying motivations to pledge their patents to the EcoPC. As will be explained in detail in Section 2, firms maintain ownership of their pledged patents, which implies that they have to bear the recurrent costs associated with patent ownership in the form of renewal fees. It is, therefore, far from obvious which benefits accrue to firms from the EcoPC scheme that outweigh the direct and indirect (e.g., management time) financial costs associated with keeping pledged patents in force. Therefore, understanding firms' motives to pledge and keep patents in force sheds light on the effectiveness and sustainability of the commons as a hybrid form of appropriation in addressing both the knowledge and environmental externalities involved in climate change related innovation.

To answer these questions, the present paper explores the characteristics of the patents that have been contributed to the EcoPC and compares them to two other sets of patents: 1) patents held by the pledging firms that are not donated to the commons and 2) a randomly drawn set of patents in the same technology (which also share priority year and authority with EcoPC patents). The first comparison sheds light on the question of where these patents fit in the firms' patent portfolios and hence give some indication on firms' underlying motivations to pledge these patents. Whereas the second informs us about how the value of these patents compares with other similar patents that have not been donated to the commons and provides information on their diffusion and potential to induce follow-on innovation by third parties.

We believe that a detailed study of the pledged patents will provide insights into the open innovation-patenting relationship in the climate change technology area, insights that may also be useful in other areas where open innovation exists side-by-side with IP protection. In particular, we provide insights into the ability of such hybrid private initiatives to address the double externality problem present in climate change related innovation.

We begin the paper with a discussion of the history and detailed operation of the eco-patent commons. Section 3 reviews different theoretical motivations for firms to pledge their climate change related patents. Section 4 discusses our approach to investigating the effect of the non-assertion pledge on technology diffusion and innovation. Section 5 describes the data used in our analysis. Section 6 discusses our results and Section 7 concludes.

2. The Eco-Patent Commons

The initial creation of the not-for-profit initiative EcoPC is quite recent, in January 2008. It was established by IBM in cooperation with the World Business Council for Sustainable Development (WBCSD) and it allows companies to pledge patents that protect green technologies. Companies as well as individuals can join the commons by pledging at least one patent.[7] Any patent is welcome that protects a technology that confers directly or indirectly some environmental benefit – so-called green patents. "Green" is defined by a classification listing IPC subclasses that are considered to describe environmentally friendly technologies. Yet there appears to exist considerable flexibility as long as a pledging firm can show some (direct or indirect) environmental benefit of the pledged patent. In fact, as we show later, many of the patents contributed appear to be directed towards mitigating environmental damage from manufacturing, but not specifically towards climate change mitigation.

"Pledge" in this context means making patents available for use by third parties free of charge, although the ownership right remains with the pledging party which distinguishes the EcoPC from conventional patent commons. This also implies that the non-assertion pledge cannot be treated as a patent donation and hence the pledged patent is not deductable from a company's taxable income. Potential users do not have to specifically request a license; any pledged patent is automatically licensed royalty-free provided it is used in a product or process that produces some environmental benefit.

While a pledge is in principle irrevocable,[8] there is a built-in mechanism to safeguard a pledging firm's business interests which is called "defensive termination". This means that a pledging firm can "terminate" the non-assertion pledge if a third party that uses a pledged patent asserts its own patent against the pledging company. The possibility to invoke "defensive termination" does not apply to other pledging firms in the commons unless the primary IPC of the asserted patent is on the commons IPC classification list. The fact that companies retain ownership rights also means that they have to bear the cost of

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[7] According to the "Ground Rules" (http://www.wbcsd.org/web/projects/ecopatent/EcoPatentGroundRules.pdf), also "any worldwide counterparts" to the pledged patent are considered to be subject to the non-assertion pledge, i.e., any equivalents to the pledged patent.

[8] The "Ground Rules" (http://www.wbcsd.org/web/projects/ecopatent/EcoPatentGroundRules.pdf) stipulate that "[a] patent approved for inclusion on the Patent List cannot be removed from the Patent List, except that it may be deleted for so long as the patent is not enforceable." However, firms obviously can withdraw from the commons at any point in time, although even in this case "[v]oluntary or involuntary withdrawal [from the commons] shall not affect the non-assert as to any approved pledged patent(s) the non-assert survives and remains in force."

maintaining the IP right, that is, they must pay any fees required to keep the patent in force.[9]

The initial members of the commons when it was launched in January 2008 were IBM, Nokia, Pitney Bowes, and Sony. In September 2008, Bosch, DuPont, and Xerox joined. Ricoh and Taisei entered the commons in March 2009 and Dow Chemical and Fuji-Xerox in October 2009. Its newest member, Hewlett Packard (HP) joined in July 2010, but is excluded from our analysis because our data is as of April 2010 and thus predates HP's entry into the commons. All patents pledged to the EcoPC are listed in an online data-base (the data base is reproduced in Appendix A1).

EcoPC is currently the only initiative of this type, although Creative Commons in collaboration with Nike and Best Buy is setting up the Green Xchange initiative. In this new initiative (in contrast to the EcoPC), pledging firms can choose whether to charge a fixed annual fee for the use of a pledged patent. Contributing firms can also selectively deny other firms the use of a pledged patent. In addition, registration of users of contributed patents is mandatory. As a matter for future research, it would be interesting to investigate whether the institutional design of the Green Xchange is more conducive to the achievement of the objective that both commons share.

To reiterate the official objective of the EcoPC laid out in the Introduction: the EcoPC aims to promote the sharing of climate-change related technologies and thus to assist in environmental protection for the common good. The initiative targets green patents that are either not used or do not represent "an essential source of business advantage" to their owners. Hence, the commons does not ask firms to sacrifice patents of particular business value for the common good. It should therefore attract those patents that are neither "worked" nor confer a strategic value to the company even as a "dormant" property right (see also Section 3). The initiative endeavors to emphasize potential business benefits for firms from participating in the commons: it can serve as a way of diffusing a technology and potentially lead to new collaboration and business opportunities as summarized by Wayne Balta, Vice President of Environmental Affairs at IBM:

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[9] When a patent is applied for at the EPO, renewal fees must be paid to the EPO beginning the third year counted from the date of filing until the patent is granted. Once the patent has been granted, renewal fees have to be paid to the national offices separately in which the patent has been validated. The renewal fees at the EPO currently vary between EUR 420 and EUR 1,420 depending on how long the application has been pending (see Supplement 1 to OJ EPO 3/2010). Renewal fees in national offices vary substantially, as of August 2010, for example in the UK, fees increase during the 20 years of patent validity from GBP 70 to GBP 600, whereas in Germany, fees increase from EUR 70 to EUR 1,940. Maintenance of a patent family can thus be thus quite costly if annual fees have to be paid at several patent offices. Contrary to the EPO and European national offices, at the USPTO, renewal fees are not payable annually. At 3.5 years, the maintenance fees due amount to US$ 980, at 7.5 years to US$ 2,480 and at 11.5 years to US$ 4,110.

> "For companies who choose to participate in this, this can be a catalyst for further innovation and collaboration. [...] it becomes an efficient channel for sharing this knowledge that you have with others so that you make known to others that you have had demonstrable expertise on a given technical problem. And you stand ready to work with them and help diffuse it further. [...] It can be a win for innovators in other parts of the world, who might look at these ideas and further them and use them as the basis of additional solutions. And it can be a win for those who pledge because it could open up opportunities to collaborate with people that you might not otherwise have collaborated with."
>
> (Wayne Balta, Vice President of Environmental Affairs, IBM)

But most importantly, participation in the scheme guarantees broad public visibility considering the great deal of (mostly positive) attention in the press the initiative has received so far (NY Times 31 October 2009; Wall Street Journal 14 January 2008; WIPO Magazine April 2009) and innumerable postings and discussions in blogs and climate-change/open-innovation online forums.

However, a number of these press articles and blog postings contests the value of the initiative. For example, the Wall Street Journal (14 Januray 2008) notes that the environmental benefit is not obvious for some of the EcoPC patents. As a case in point, the press article provides the example of a patent pledged by Pitney Bowes "that protects electronic scales from being damaged when they are overloaded."[10] In a review of the EcoPC initiative, Srinivas (2008) lists a number of problems with the initiative. He argues that the technologies protected so far by patents in EcoPC "have a very limited application in the further development of technologies in key sectors." However, he does not provide any proof for this assertion. Related to this, he claims that more important players in the market for climate-change related technologies have to join the commons in order to make it an effective tool for the dissemination of relevant technologies. He is also skeptical that simply providing royalty-free access to single green patents will have a significant impact on the diffusion of green technologies as most technologies are covered by multiple patents which are not included in the commons. Cronin (2008) argues in her article in Greenbizz that the patents contained in the EcoPC are of little value as they protect outdated technologies. She also asks the natural question of why private companies would give something valuable away for free:

> [I]t is clear that the donating company did not find the patent to have compelling competitive advantage for them, or they would not have donated it to begin with, so why would any other company necessarily find value in the donated patent?
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> (Nancy Cronin, Greenbizz - April 2008)

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[10] This patent is a bit of an exception. It is the only one of the patents for which we also could not ascertain the environmental benefit easily. It seems that there is some energy-saving consequence to preventing overload on electronic scales.

As a solution to this problem, Cronin suggests including novel non-patented inventions that have not been made public before, presumable because they were protected via trade secrecy. This could be done in the form of defensive publications, which are currently not part of the EcoPC.

However, the issue is even more puzzling, because firms actually pay to provide royalty-free access to their patents. This baffling aspect of the structure of the commons is best highlighted in the following quote by Duncan Bucknell of Think IP Strategy:

> Why would a patent owner contribute a patent, continue to sustain the maintenance costs, yet have the patent commonly available to all having undertaken to not enforce the patent? Why not just allow the patent to lapse (telling the world that you're doing that to free-up availability of the technology for the greater good to bank the PR benefit)?
>
> (Duncan Bucknell, Think IP Strategy - March 2008)

The relevant question therefore is why firms would find it worthwhile to allow non-exclusive royalty-free licenses to a set of patents while simultaneously incurring the cost of keeping them in force? Why not simply allow the patents to lapse, effectively publishing the contents defensively? Is the value of possible defensive termination against future threats that large?

In the academic literature, so far, only Van Hoorebeek and Onzivu (2010) discuss the EcoPC initiative. They regard it as a private response to calls by mostly developing countries for increased climate change related technology transfer. As such, the EcoPC initiative may help deflect increasing pressure exerted by developing countries to apply TRIPS provisions including compulsory licensing or even denying patent protection to specific climate change related to technologies. But for this strategy to be viable, patents pledged under the EcoPC initiative should protect enforceable and "valuable" technologies, an assumption that Van Hoorebeek and Onzivu (2010) do not investigate in their qualitative discussion.

More generally, there has been some discussion in the strategic management literature on patent pledges in the context of software. Alexey and Reitzig (2010), for example, argue that firms may choose to pledge patents to mould the wider appropriability regime that governs their business activity. Using software patents as an example, the authors argue that firms which stand to profit from the open source software concept through the production of complementary assets, such as IBM and Nokia, choose to unilaterally pledge patents in order to create an appropriability regime conducive to the open source movement. The establishment of a patent commons would seem consistent with this reasoning as it would enable firms to address the collective action problem involved in shifting the appropriability regime. Since the EcoPC firms are not major players in the market for green technologies, shifting the appropriability regime governing green technologies might thus even be beneficial as it could harm potential competitors and induce sales of complementary assets provided by EcoPC firms. Nevertheless, the underlying assumption in this argument is again that firms pledge "valuable" patents.

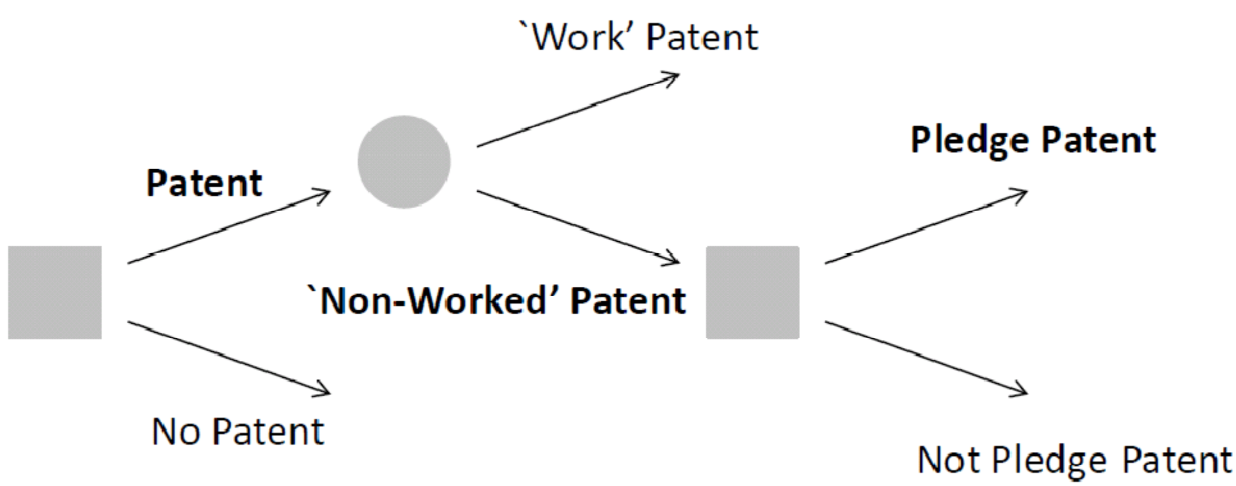
Biotechnology, a research field in which IP protection of key technologies appears to have detrimental effects on innovation (Lei et al., 2009), offers another example of a similar initiative: the BiOS (Biological Open Source) initiative by the not-for-profit institute CAMBIA. In the case of BiOS, firms may use patented technologies royalty-free but agree to "share with all BiOS licensees any improvements to the core technologies as defined, for which they seek any IP protection" and "agree not to assert over other BiOS licensees their own or third-party rights that might dominate the defined technologies" (Jefferson, 2006: 459). The strength of this initiative appear to rest largely on the value of the IP rights available under BiOS licenses.

In summary, the EcoPC initiative provides an institutional design that allows easy access to patented technologies, which may confer some direct or indirect climate change related benefits. It is, however, far from obvious whether the pledged patents protect any valuable green technologies as the motives for firms to pledge valuable green patents and keep them in force are not clear-cut.

3. Why do firms contribute?

Figure 1 shows schematically the decision tree of a firm contemplating working a patent or abandoning it and its decision to pledge the patent to the EcoPC.

Figure 1: Firm's decision tree



Unfortunately, we only observe some of these decisions. Among the four final outcomes (a - no patent, b - work the patent, c - pledge the patent, d - neither work nor pledge the patent), we observe only c and the combination of b and d. This limits our ability to build a structural model of the decision process. Conditional on patenting, we can, however, say the following:

1. The firm is more likely to work the patent if it is valuable, if more resources were invested in acquiring it, and if it is related to the firm's own line of business or technology expertise.
2. The firm is more likely to pledge a patent if it is environmentally friendly, if it is less related to the firm's own line of business or technology expertise, and if it is not suitable for licensing.

Taken together, this suggests that a firm's pledged patents will be less valuable, more "green", and less related to the firm's patent portfolio. We might also expect that these patents are less likely to be prosecuted aggressively if they have not yet issued, and that they are less likely to remain in force. If firms (ab)use the commons purely for public relation motives, we would expect to see pledged patents to lapse, i.e., not to be in force, shortly after entering the EcoPC because presumably most PR benefits are reaped at the moment when the pledge is announced.

Hence, while a firm's decision to `work' a patent remains unobserved, we can nevertheless deduce from the characteristics of the pledged patents themselves (notably their legal status) as well as relative to other patents held by the same firm or patents in the same technology field what a firm's underlying motives for pledging patents are.

4. Technology Diffusion and Follow-on Innovation

If we find in the analysis described in Section 3 that EcoPC patents indeed protect valuable climate change related technologies, the relevant question is whether pledging these patents has had an impact on the diffusion of the protected technologies and has spurred the development of new innovation which is based on the pledged patents.

There are at least two challenges in assessing the effect of the commons on diffusion and innovation. First, diffusion in terms of application of the protected technologies in question cannot be captured. According to the regulations of the EcoPC, third parties are allowed to use pledged patents without signaling this to the patent owners. Hence, if a third party applies an EcoPC patent in a process or product, we are unable to observe this unless the third party cites the EcoPC patent in a patent application aimed at protecting the new process or product. It is important to emphasize that this may substantially undermine our ability to investigate the impact of the non-assertion pledge on pure diffusion without additional innovation for which patent protection is sought. Second, we observe patents for at most two years after they have been pledged. This represents a short amount of time that these patents have been freely accessible. Considering the possible long lag time in the development of new technologies based on existing patents and the 18 month period between application and publication date, this may limit our ability to find patents that build on the EcoPC patents after they have entered the commons. For this reason, we limit this part of the analysis to patents pledged by IBM, Nokia, Pitney Bowes, and Sony, which entered the commons in January 2008.[11]

Mindful of these limitations, we resort to a difference-in-difference research design to investigate this question. We observe all patents before and after they have been pledged and therefore analyze whether there are statistically significant differences in the pattern of forward citations these patents receive before and after they entered the commons. If royalty-free access has had an impact on diffusion of these technologies, we would expect to see a statistically significant increase in the forward citations that the EcoPC patents have received subsequent to their pledge. We use two different control groups: control (1) sample which contains all patents held by the same firm and control (2) which covers all patents in the same technology class. Subtracting changes in the citation pattern of EcoPC patents from those of the control groups removes biases that would arise if there were group-specific differences or time trends. The model that we estimate is therefore specified as follows

$$cit_{it} = \delta_t + \beta EcoPC_{it} + x_{it}\gamma + \varphi_i + \varepsilon_{it} \qquad (1)$$

Where i indexes individual patents and t denotes time. δ_t is a time trend. Individual patents' characteristics enter through the vector x_{it}. The model also allows for unobserved individual effects φ_i. The effect of entry into the EcoPC is captured through β, which represents the difference in mean outcomes of the EcoPC and control group patents.

The main problem with estimating equation (1) is that the dummy variable $EcoPC_{it}$ is unlikely to be strictly exogenous. For example, if more forward citations made it less likely for a patent to be pledged to the EcoPC, strict exogeneity required to estimate (1) by OLS would be violated and our estimate of β biased.

5. Data and Descriptive Statistics

The data appendix A describes in detail how we created our dataset and control samples. We started with the list of 121 patents contributed to the EcoPC by the 12 contributing

[11] The next group of firms, Bosch, DuPont, and Xerox, joined the EcoPC only in September 2008. Given the 18 months lag between application and publication and the fact that we use PATSTAT version April 2010, this means that forward citations for EcoPC patents by these firms may not even be visible after the they have been pledged to the EcoPC.

firms which is available on WBCSD's website.[12] We then used the April 2010 edition of EPO's PATSTAT to draw the following samples of patents:

1. All of the patents with the same set of priority documents as the EcoPC patents, i.e., all EcoPC equivalents.[13]
2. Control (1) sample: all patent applications worldwide that were made by the 12 EcoPC firms.
3. Control (2) sample: all patent applications worldwide in the same IPC class as one of the EcoPC patents (which also share the same priority year and authority as an EcoPC patent).

A number of complications arose in performing these tasks. First, PATSTAT is based on published applications, whether or not the patents have been granted. This is an advantage because most of our EcoPC patents are of fairly recent date and may not yet have been granted. However, not all US application are published at 18 months, especially in the earlier part of our sample. Even if they are published, it appears that some firms leave the assignment of ownership off the application until the patent issues, so we will not find all the patent applications that correspond to a given firm. We test whether this makes a difference for the control (1) sample later in the paper.

A second problem is missing priorities. Many of these patents have multiple equivalents, which are patents applied for in several jurisdictions on the same invention. We prefer to perform our analysis using only a single observation for each "invention," preferably the priority application. However a large number of patents are missing priorities and in this case we simply allowed the patent to serve as its own priority, effectively keeping it as a single patent with no equivalents. We have checked this assumption using the equivalents data constructed by Dietmar Harhoff and co-workers and found that it introduces very little error into the data.[14]

Thirdly, PATSTAT does not provide information on the legal status of a patent. It can be inferred from a patent's publication kind code whether it has been granted; however, if a patent has not been granted, it is difficult to infer whether the patent application has been rejected, lapsed, or is simply still pending. Moreover, there is no information on whether

[12] Some of the patent numbers given on WBCSD's website were incorrect. We retrieved the correct numbers either by searching for the patents using the patent titles indicated on the website or by obtaining the information directly from contacting WBCSD. We thank Kana Watanabe at IBM's Corporate Environmental Affairs for assisting in the retrieval of the missing information.

[13] The priority years ranged from 1989 to 2005, so we restricted the matching samples Control (1) and Control (2) to those years.

[14] All the additional equivalents for our eco-patents that were found this way were for unpublished patent applications, which are not in our sample. See http://www.inno-tec.bwl.uni-muenchen.de/forschung/forschungsprojekte/patent_cit_project/index.html for the equivalents data.

renewal fees have been paid. This made is necessary to collect information on patents' legal status manually from EPO's INPADOC, USPTO PAIR, and the various national patent offices.

In this section of the paper we present some basic information about the patents contributed to the commons: their ages, legal status, priority authorities, family sizes, the technology areas, and the firms contributing them. Table 2 shows the number of patents contributed by each of the 12 firms, both uncorrected and corrected for equivalents. These patents are a tiny share of the firm's portfolio (less than 0.1 per cent) and the majority of the patent families (81 out of 96) have been contributed by four firms: Bosch, DuPont, IBM, and Xerox. In appendix Table A3 we show that in almost all cases the priority patent was applied for at the USPTO, the German patent office, or the JPO, and in most cases at the office corresponding to the headquarters of the applicant. Table 2 also shows the date that each firm entered the commons; to the best of our knowledge this is also the date that all their patents were contributed. The dates are all quite recent, so we have only two years at most to observe these patents after donation, with the inevitable consequence that our analysis will be preliminary, but we believe it is useful to set the stage for subsequent analysis performed after some more time has passed.

Table 3 gives a rough idea of the technologies that have been contributed. This table is based on a reading of the abstract and written description of these patents, with a special focus on the description of the problem to be solved, in order to determine their likely application. Two related observations about the data in this table suggest themselves: first, only slightly more than one-third of these patents fall into classes that are designated as a clean technology class by the OECD-EPO definition (Johnstone *et al.*, 2010).[15] Second, many of them seem to be related to environmental cleanup or clean manufacturing, and only tangentially to mitigating the effects of global climate change.

The ages of the contributed patents at the time of their donation vary widely. A few are old and nearing the end of their life, but many have substantial statutory life remaining (Figure 1). Age is measured as the exact date the owning firm joined the commons less the exact priority date of the patent. In general, the statutory life of the patents will be twenty years from the date of application (which often coincides with the priority date), and we find a range from 3 years to 20 year, with a peak at 4 years of age. This is suggestive, as most patents are granted by the time the application is four years old, and this age also corresponds roughly to the time when much uncertainty about potential value of the invention is likely to have been resolved (Lanjouw *et al.*, 1998).[16] In Figure 2, we show the priority years of the contributions as a share of the 12 firms' patents and also as a share of

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[15] The relevant IPC classes are available at
http://www.oecd.org/document/55/0,3343,en_2649_34333_43383927_1_1_1_1,00.html

[16] EPO patents typically take longer to grant than four years, but are relatively underrepresented in our sample, which consists primarily of USPTO, German patent office, and JPO patent applications and grants.

patents in the relevant classes. Both follow the same pattern, with a slow decline between 1989 and 2003, and then a sharp increase in contribution rate in the years 2004 and 2005.

One of the questions raised by the commentators quoted in the introduction was whether and why firms would pay to keep a patent in force once it was contributed to the commons. Because many of the donations are quite recent, it is difficult to observe whether firms have chosen to pay renewal fees on their patents after they have been donated. It is also the case that many of these patents have not even been granted as of April 2010. In Table 4, we look at the legal status of all the equivalent patents where we have collected the data manually from the relevant patent offices as described above. It appears that almost 60 per cent have been granted and are still in force, 13 per cent are pending, and almost 30 per cent are withdrawn, rejected by the relevant office, or have expired.[17] So in fact it does appear that in some cases the applicants have chosen to abandon the donated patents before their statutory term has expired, or have chosen not to prosecute them aggressively.

The descriptive statistics provided in this section suggest that a substantial share of EcoPC patents have been granted are maintained in force. In any case, most patents that enter the commons are young and still have substantial statutory lifetime. The technologies covered by the EcoPC patents appear to be climate change related, although this is a matter of interpretation as the OECD clean technology definition categorizes only a third of the EcoPC patents as climate change related. We also showed that the EcoPC patents account for tiny shares in EcoPC firms' patent portfolios. Considering the size of the patent portfolios held by firms such as IBM or Sony, this is hardly a surprising result. The following section investigates firms' motives to pledge the EcoPC patents and if pledging the property rights has had a discernible impact on the diffusion of the protected technologies.

5. Results

6. Conclusions

[17] As best we can determine, the NA category corresponds to those patent applications that have not yet been examined by the relevant office, either because they are newer, or, in some cases, because examination was not requested by the applicant. The patent offices concerned are Japan, Russia, and Mexico.

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Data Appendix

A 1: List of Patents contained in Eco Patent Commons

#	*Description*	*Number*	*Equivalents*	*Pub Auth*	*Company*	*IPC*
1	Fuel injection valve for internal combustion engine, with actuator acting via needle carrier on valve needle	EP1084344	DE19915210, JP2002541375, US6575385, WO60232	Germany	Bosch	B05B001-08
2	Fuel injection valve for internal combustion engine, with actuator acting via needle carrier on valve needle	US6575385	DE19915210, EP1084344, JP2002541375, WO60232	Germany	Bosch	B05B001-08
3	Fuel injection valve for internal combustion engine, with actuator acting via needle carrier on valve needle	DE19915210	EP 1084344, JP2002541375, US6575385, WO60232	Germany	Bosch	B05B001-08
4	Fuel injection valve for internal combustion engine, with actuator acting via needle carrier on valve needle	JP2002541375	DE19915210, EP1084344, WO60232, US6575385	Germany	Bosch	B05B001-08
5	Piezoelectric fluid viscosity sensor	EP1393041	DE10123040, *WO02093136*, US2003217589, *JP2004519695*, US6755073	Germany	Bosch	G01N011-16
6	Piezoelectric fluid viscosity sensor	*JP2004519695*	DE10123040, *WO02093136*, EP1393041, US6755073, US2003217589	Germany	Bosch	G01N011-16
7	Piezoelectric fluid viscosity sensor	DE10123040	*WO02093136*, US2003217589 EP1393041, *JP2004519695*, US6755073	Germany	Bosch	G01N011-16
8	Piezoelectric fluid viscosity sensor	*WO02093136*	DE10123040, US2003217589, EP1393041, *JP2004519695*, US6755073	Germany	Bosch	G01N011-16
9	Piezoelectric fluid viscosity sensor	US6755073	DE10123040, *WO02093136*, US2003217589, EP1393041, *JP2004519695*	Germany	Bosch	G01N011-16
10	Climate control system in vehicle with heating and cooling circuits	EP1536961	WO2004024479, DE10240712, *KR2005004862*, *US2006081355*	Europe	Bosch	B60H001-00
11	Climate control system in vehicle with heating and cooling circuits	*DE10240712*	WO2004024479, EP1536961, *KR2005004862*, *US2006081355*	Germany	Bosch	B60H001-00
12	Climate control system in vehicle with heating and cooling circuits	*KR20050048623*	*DE10240712*, EP1536961, WO2004024479, *US2006081355*	Korea	Bosch	B60H001-00
13	Climate control system in vehicle with heating and cooling circuits	*US2006081355*	*DE10240712*, EP1536961, *KR2005004862*, WO2004024479	United States	Bosch	B60H001-00
14	Apparatus for removing contaminants from	EP1070555		Europe	Xerox	B09C

	a contaminated area					
15	Image Forming Device	JP3375028		Japan	Ricoh	G03G
16	Method for recycling optical disks	JP3528898		Japan	Sony	B01D
17	The purification method and purges of shallow water regions	JP3561890		Japan	Taisei	C02F
18	Metallic reflection film recovering device of disklike information recording M medium and its metallic reflection film recording method	JP3704899		Japan	Sony	B01D
19	Method and device for extracting groundwater using high vacuum	JP3095851	EP498676, US5172764	Japan	Xerox	E03F
20	Recycling of disk-like information	JP3855377		Japan	Sony	B08B
21	Flocculating agent and a method for flocculation	JP3876497		Japan	Sony	B01D
22	Method and apparatus for removing contaminant	JP3805414	EP707899, DE69510746	Japan	Xerox	B09C
23	Process for removing contaminants and apparatus therefore	JP3884793	EP747142, DE69629854, DE69612321	Japan	Xerox	B09C
24	Device for extracting contaminated material from discharged stream and method thereof	JP3971480	US6024868, EP792700	Japan	Xerox	B09C
25	The constructing method of the artificial green space of the watersides	JP4015958		Japan	Taisei	E02B
26	Motor cable with ferromagnetic casing	DE4027948	BR 9103806, *JP4234558*, US5197444	Germany	Bosch	F02D033-00
27	Motor cable with ferromagnetic casing	BR9103806	DE4027948, *JP4234558*, US5197444	Brazil	Bosch	F02D033-00
28	Motor cable with ferromagnetic casing	*JP3242425*	DE4027948, BR9103806, US5197444	Japan	Bosch	F02D033-00
29	Motor cable with ferromagnetic casing	US5197444	DE4027948, BR9103806, *JP4234558*	United States	Bosch	F02D033-00
30	Hydraulic drive for sheet metal forming machine	DE4218952		Germany	Bosch	B03B015-18
31	Channel-scanning cordless telephone appts. with microprocessor- begins scanning with particular radio channel assigned to mobile and base stations among number of channels selected by operator.	DE4241838	WO9414272, EP0626118, *JP7503835*, KR100274286	Germany	Bosch	H04B007-26
32	Channel-scanning cordless telephone appts. with microprocessor- begins scanning with particular radio channel assigned to mobile and base stations among number of channels selected by operator.	*EP0626118*	DE4241838, WO9414272, *JP7503835*, KR100274286	Germany	Bosch	H04B007-26
33	Channel-scanning cordless telephone appts. with microprocessor- begins scanning with particular radio channel assigned to mobile and base stations among number of channels selected by operator.	JP3466190	DE4241838, EP0626118, KR100274286	Germany	Bosch	H04B007-26
34	Channel-scanning cordless telephone appts. with microprocessor- begins scanning with particular radio channel assigned to mobile and base stations among number of channels selected by operator.	*KR100274286*	DE4241838, EP0626118, *JP7503835*, WO9414272	Germany	Bosch	H04B007-26
35	Method of anisotropically etching silicon wafers and wafer etching solution	US4941941	KR940008369, JP3126227, JP7013956,	United States	IBM	H01L

			EP421093, DE69022944, CN1052513, CN1024148, AU6314190, AU636388			
36	Water soluble solder flux and paste	US5011546	JP4228289, JP7075788, EP452009	United States	IBM	B23K
37	Process for two phase vacuum extraction of soil contaminants	US5050676	EP420656, JP3202586, DE69029314	United States	Xerox	E21B
38	Tape drive cleaning composition	US5080825	EP432878, MX169000, JP3146596, HK71996, ES2081355, DE69024471, CN1051585, CN1095873, CA2024636, BR9005251	United States	IBM	C11D
39	Process and Apparatus For Groundwater Extraction Using a High Vaccum Process	US5172764	EP498676, MX9102041, JP4309626, ES2101804, DK498676, DE69219492, CA2053446, BR9200046, AT152645	United States	Xerox	E21B
40	Apparatus for two phase vacuum extraction of soil contaminants	US5197541		United States	Xerox	E21B
41	Catalyst Method for the Dehydrogenation of Hydrocarbons	US5258348	WO9106366 , JP5504907, EP495857, DE69015824, CA2067390, BR9007795, AT116572	United States	Dow	B01J
42	Chemical pre-treatment and biological destruction of propylene carbonate waste streams effluent streams to reduce the biological oxygen demand thereof	US5275734	JP6106183, EP582539	United States	IBM	C02F
43	Solvent stabilization process and method of recovering solvent	US5310428	JP6262003, EP605350	United States	IBM	B08B
44	Supported Catalyst for Dehydrogenation of Hydrocarbons and Method of Preparation of the Catalyst	US5354935		United States	Dow	C07C
45	Process and apparatus for high vaccum groundwater extraction	US5358357	EP622131, EP5464309, DE69428547, DE69407333	United States	Xerox	E03B
46	Packaging system for a component including a compressive and shock-absorbent packing insert	US5439779		United States	IBM	G03C
47	Apparatus and process for treating contaminated soil gases and liquids	US5441365		United States	Xerox	B09B
48	Dual wall multi-extracion tube recovery well	US5464309	EP622131, US5358357, DE69428547, DE69407333	United States	Xerox	E03B
49	Ink-jet printer having variable maintenance algorithm	US5521334	GB2296574, DE19548919, CA2165758	United States	Pitney Bowes	G01G

50	Aqueous soldermask	US5571417		United States	IBM	C02F
51	Method for treating photolithographic developer and stripper waste streams containing resist or solder mask and gamma butyrolactone or benzyl alcohol	US5637442		United States	IBM	B01D
52	Magnetic Refrigerant Compositions and Processes for Making and Using	US5641424	EP753866, MX9602129, JP9033129, ES2162976, DE69616184, BR9603037, AR2429	United States	Xerox	G03G
53	High vacuum extraction of soil contaminants along preferential flow paths	US5655852	US5709505, JP7290038, EP679450, DE69505179	Europe	Xerox	E02D
54	Highly sensitive method for detecting environmental insults	US5683868	WO9413831, KR100262681, JP8504101, IL107815, ES2102811	United States	DuPont	C12Q, C12N
55	Lyophilized bioluminescent bacterial reagent for the detection of toxicants	US5731163	WO9616187, JP10509049, EP793729, DE69527850, CA2200702, AT222605	United States	DuPont	C12Q, C12N
56	Method for treating photolithographic developer and stripper waste streams containing resist or solder mask and gamma butyrolactone or benzyl alcohol	US5824157		United States	IBM	B05C
57	Fluid jet impregnation	US5863332		United States	IBM	B05C
58	Vacuum application method and apparatus for removing liquid contaminants from groundwater	US5979554	EP911071, JP11207101, DE69835928	United States	Xerox	E21B
59	Fluid jet impregnating and coating device with thickness control capability	US5994597		United States	IBM	C07C
60	Process for recovering high boiling solvents from a photolithographic waste stream comprising less than 10 percent by weight monomeric units	US6021402		United States	IBM	G06F
61	Air flow control circuit for sustaining vacuum conditions in a contaminant extraction well	US6024868	JP9225448, EP792700, DE69714101, BR9701080	United States	Xerox	C02F
62	Multiple overload protection for electronic scales	US6045206	EP934828, CA2261284	United States	Pitney Bowes	G07B
63	Automatic aspirator air control system	US6048134	EP928642, JP11253785, DE69909534	United States	Xerox	B09B
64	Risk management system for electric utilities	US6127097		United States	IBM	G03F
65	Photoresist develop and strip solvent compositions and method for their use	US6178973		United States	IBM	B08B
66	Method and apparatus for ozone generation and surface treatment	US6187965	KR20000035014	United States	IBM	C07C
67	Process for recovering high boiling solvents from a photolithographic waste stream comprising at least 10 percent by weight of monomeric units	US6197267		United States	IBM	F01N
68	Catalytic reactor	US6210862	US2002177072,	United	IBM	G03F

			US6576382	States		
69	Composition for photoimaging	US6221269		United States	IBM	C03C
70	Method of etching molybdenum metal from substrates	US6294028		United States	IBM	C23G
71	Mercury process gold ballbond removal apparatus	US6419566		United States	IBM	B24C
72	System for cleaning contamination from magnetic recording media rows	US6426007		United States	IBM	C02F
73	Removal of soluble metals in waste water from aqueous cleaning and etching processes	US6440639		United States	IBM	G03C
74	Method for deterring drive voltage of fuel injection valve piezoelectric actuator	US6499464	DE10032022, GB2364400, JP2002070683, FR2811016, GB2364400	United States	Bosch	F02D041-20
75	Method for deterring drive voltage of fuel injection valve piezoelectric actuator	DE10032022	GB2364400, JP2002070683, US6499464, FR2811016, US2002046734	Germany	Bosch	F02D041-20
76	Method for deterring drive voltage of fuel injection valve piezoelectric actuator	GB2364400	DE10032022, JP2002070683, US6499464, FR2811016, US2002046734	UK	Bosch	F02D041-20
77	Method for deterring drive voltage of fuel injection valve piezoelectric actuator	JP2002070683	DE10032022, GB2364400, US6499464, FR2811016, US2002046734	Japan	Bosch	F02D041-20
78	Method for deterring drive voltage of fuel injection valve piezoelectric actuator	FR2811016	DE10032022, GB2364400, JP2002070683, US6499464, US2002046734	France	Bosch	F02D041-20
79	High-aspect ratio resist development using safe-solvent mixtures of alcohol and water	US6503874		United States	IBM	B08B
80	Cleaning method to remove flux residue in electronic assembly	US6576382	US6210862	United States	IBM	G03F
81	Composition for photoimaging	US6585906		United States	IBM	B44C
82	Cellular Arrays for the Identificaiton of Altered Gene Expression	US6716582	US2004146922, US2004142373	United States	DuPont	C12Q
83	Method for recycling a disk having a layered structure on a glass substrate	US6800141		United States	IBM	B08B
84	Semi-aqueous solvent based method of cleaning rosin flux residue	US6891640	JP2003136811	United States	IBM	G06K
85	Apparatus and method for reusing printed media for printing information	US6997323		United States	IBM	B65D
86	Method to accelerate biodegration of aliphatic-aromatic copolyesters by enzymatic treatment	US7053130		United States	DuPont	C08G, C08J
87	Systems and methods for recycling of cell phones at the end of life	US7251458	EP1480419, AT402558	United States	Nokia	H04B
88	1,1,1,2,2,4,5,5,5- Nonafluoro-4-(Trifluoromethyl)-3-Pentanone Refrigerant Compositions Comprising a Hydrofluorocarbon and Uses Thereof	US7314576	US2005263737, US7153448	United States	DuPont	C09K
89	1,1,1,2,2,4,5,5,5- Nonafluoro-4-(Trifluoromethyl)-3-Pentanone Refrigerant Compositions Comprising a Hydrocarbon and Uses Thereof	US7332103	US2005263738, US7094356	United States	DuPont	C09K
90	1,1,1,2,2,4,5,5,5- Nonafluoro-4-	US7338616	US2005263735,	United	DuPont	C09K

	(Trifluoromethyl)-3-Pentanone Refrigerant Compositions Comprising a Hydrofluorocarbon and Uses Thereof		US7074343	States		
91	1,1,1,2,2,3,3,4,4- Nonafluoro-4-Methoxybutane Refrigerant Compositions Comprising Functionalized Organic Compounds and Uses Thereof	US7351351	US2005285076, WO2006012096, US2008169446, RU2007103192, NO20070398, MXPA6014218, KR2007003908, JP2008505212, EP1771526, CA2565349, BRPI0512456, AU2005267439	United States	DuPont	C09K
92	1,1,1,2,2,3,3,4,4- Nonafluoro-4-Methoxybutane Refrigerant Compositions Comprising a Hydrofluorocarbon and Uses Thereof	US7354529	US2005151112	United States	DuPont	C09K
93	Protecting exhaust gas conducting parts of IC engine	DE10211152		Germany	Bosch	F02B005-02
94	Electric current generator for motor vehicle	DE10214614		Germany	Bosch	H02K007-116
95	Mapping route in navigation system	DE102004022265	EP1593937	Germany	Bosch	G01C02-34
96	Production of a filter element of a particle filter for an internal engine	DE102004028887	WO2005123219	Germany	Bosch	B01D039-00
97	Production of region of filter structure for a particle filter	DE102004035310	WO2006008209	Germany	Bosch	B01D039-20
98	Device for fuel-saving through electrical energy management controls load(s)	DE102004038185		Germany	Bosch	H02J001-00
99	Filter for removing particles from a a gas stream	DE102004044338	WO2006027289	Germany	Bosch	B01D046-24
100	Equalizing process for Lambda values of engine cylinders	DE102005005765		Germany	Bosch	F02D041-14
101	Varnishing unit, especially for valve housing	DE102005006457	WO2006122587	Germany	Bosch	B05B005-08
102	Filter device, for an exhaust system of an internal combustion engine	DE102005006502		Germany	Bosch	F01N003-021
103	Exhaust gas sooty particles filter for diesel internal combustion engines	*DE102005035593*		Germany	Bosch	B01D046-02
104	Device for energy supply to hybrid motor vehicle	DE102005042654	WO2007028755	Germany	Bosch	B60K006-04
105	Particle filter for e.g. diesel engine	DE102005046051		Germany	Bosch	F01N003-28
106	Illuminated emergency exit sign, for a building	DE202004012616		Germany	Bosch	G09F013-18
107	Motor cable with ferromagnetic casing	DE19963301	*US2001020542*	Germany	Bosch	H01B005-18
108	Motor cable with ferromagnetic casing	*US2001020542*	DE19963301	Germany	Bosch	H01B005-18
109	Particle filter bag for use in internal combustion engine	*DE102005042207*		Germany	Bosch	F01N003-022
110	Hydrofluorocarbon Refrigerant Compositions and Uses Thereof	US7413675	US2005285074, WO2006012095, NO20070399, RU2007103169	United States	DuPont	C09K
111	1,1,1,2,2,4,5,5,5-Nonafluoro-4-(Trifluoromethyl)-3-Pentanone Refrigerant Compositions Comprising a Hydrofluorocarbon and Uses Thereof	US7479239	US2008061265	United States	DuPont	C09K
112	Wastewater Treatment Process	JP4140449	JP2004351379	Japan	Fuji-Xerox	C02F
113	Wastewater Treatment Process	US7468137	US2006283806, EP1734009, KR2006013244, JP2006346610, CN1880240, CN100484887	United States	Fuji-Xerox	C02F
114	Improved process and apparatus for high vacuum groundwater extraction	EP0622131	US5464309, US5358357,	Europe	Xerox	B09C

			DE69428547, DE69407333			
115	Vertical isolation system for two-phase vaccum extraction of soil and groundwater contaminants	*US5709505*	US5655852, JP7290038, EP679450, DE69505179	United States	Xerox	E21B
116	Vertical isolation system for two-phase vacuum extraction of soil and groundwater contaminants	EP0747142	JP8332476, DE69629854, DE69612321	Europe	Xerox	B09C
117	Improved apparatus for high vacuum groundwater extraction	EP0775535		Europe	Xerox	B09C
118	Apparatus and methods for removing contaminants	*EP0792700*	US6024868, JP9225448, DE69714101	Europe	Xerox	B09C
119	Improved process and apparatus for groundwater extraction using a high vacuum process	*EP0498676*	US5172764, MX9102041, JP4309626	Europe	Xerox	E03F
120	Apparatus for removing liquid contaminants	EP0911071	US5979554, JP11207101, DE69835928	Europe	Xerox	B01D
121	Producing particulates filter	DE102005032842		Germany	Bosch	B22F003-105

Notes:

1) Corrected numbers in italic red.

2) Underlined numbers in green added by the authors to list available on EcoPC website.

A 2: Construction of core dataset

The patent numbers given in column 3 of table in A 1 are used to extract additional information on these Eco Patent Commons (EcoPC) patents from the European Patent Office (EPO) Worldwide Patent Statistical Database (PATSTAT) version April 2010. PATSTAT combines patent information from several sources: DocDB (the EPO master bibliographic database containing abstracts and citations), PRS (the patent register for legal data), EPASYS (the database for EP patent grant procedure data), and the EPO patent register as well as the USPTO patent database for names and addresses of applicants and inventors.

In a first step, we extract from Espacenet all equivalents of the patent numbers given in column 3 of table in A 1. In a second step, we retrieve from PATSTAT all patents with the same publication number as an EcoPC patent. In a third step, we also match the publication authority and keep the record in PATSTAT that is at the most advanced stage of the grant process as indicated by its patent's publication kind. For example in the case of the US, if both A1 (first published patent application) and B1 (granted patent as first publication) documents are available,[18] we focus on the B1 document.

We then add a range of information covering the application, publication, IPC codes, applicant and inventor, priorities, and patent families as defined in DOCDB and INPADOC

[18] These definitions apply since 2001.

(for more information on patent families see Martinez, 2010). We also include backward and forward citations as well as citations of non-patent documents. Since forward citations are truncated by the Patstat version that we are using, we collect in addition the most recent forward citations from Espacenet.[19] We face the same issue in determining whether an EcoPC has been granted. Thus, we also collect the most recent available publication kind from Espacenet in order to create an indicator variable showing whether a patent has been granted. In addition, we collect information on the legal status of EcoPC patents from a various sources, including INPADOC, IPDL, KIPRIS, DPinfo, INPI, and USPTO PAIR.

A 3: Construction of comparison sample 1 (patents from same applicant)

We use a list of standardized firm names of companies that have pledged patents to the EcoPC to extract all other patents assigned to these firms from PATSTAT. Notably, we first extracted all assignee names available in PATSTAT and then filtered the nearly 37 million entries for the names of our EcoPC firms. This approach ensured that we caught all patents held by our firms regardless of the different ways in which firms names are entered into PATSTAT – we found that for some of our firms, PATSTAT included several hundred different ways in which the names are entered. We extract the same range of information on these control patents as for the core EcoPC patents (see description in A 2).

A 4: Construction of comparison sample 2 (patents with same (i) priority authority, (ii) priority year, and (iii) IPC)

The second control group is selected based on a unique list of (i) priority authority, (ii) priority year, and (iii) IPC of the EcoPC patents. This list is used to extract from PATSTAT all other patents which share features (i)-(iii) with the EcoPC patents. In a second step, we eliminated manually all individual and non-profit assignees from the control sample.[20]

[19] http://ep.espacenet.com/

[20] Individuals and non-profit owned patents were only kept in the sample when there was no equivalent patent owned by a company with the same priority and application authority, priority year and IPC code. There were seven such cases.

Table 1: Data on priorities

	Ecopatents	*Control2*	*Eco share*	*Control1*	*Eco share*
N of unique applications	238	95,894	0.25%	687,465	0.035%
N of unique priorities	96	29,228	0.33%	399,502	0.024%
N of applications with multiple priors	36	28,332	0.13%	42,388	0.085%
N of priors with multiple applns	47	21,871	0.21%	111,845	0.042%
N of unique appln-prior combinations	280	171,985	0.16%	750,497	0.037%
Average family size	2.92	5.88		1.88	

Table 2: Patents contributed to the commons compared to the contributing firms' portfolios

		All applications and equivalents			*Unique priorities only*			*Average family size in dataset*	
	Date entered the commons	*Eco-patents*	*Total patents*	*Share*	*Eco-patents*	*Total patents*	*Share*	*Eco-patents*	*Total patents*
DuPont	Jan-08	43	41,657	0.103%	14	12,729	0.110%	3.07	3.27
IBM	Jan-08	53	100,187	0.053%	29	57,282	0.051%	1.83	1.75
Mannesmann	Jan-08	2	7,128	0.028%	1	2,673	0.037%	2.00	2.67
Nokia	Jan-08	3	52,490	0.006%	1	12,900	0.008%	3.00	4.07
PitneyBowes	Jan-08	7	4,610	0.152%	2	2027	0.099%	3.50	2.27
Sony	Jan-08	4	184,764	0.002%	4	119,898	0.003%	1.00	1.54
Bosch	Sep-08	52	92,393	0.056%	23	31,154	0.074%	2.26	2.97
Xerox	Sep-08	56	28,505	0.196%	15	12,590	0.119%	3.73	2.26
Ricoh	Mar-09	1	110,526	0.001%	1	99,821	0.001%	1.00	1.11
Taisei	Mar-09	2	6,923	0.029%	2	6,789	0.029%	1.00	1.02
Dow	Oct-09	9	15,183	0.059%	2	4,342	0.046%	4.50	3.50
FujiXerox	Oct-09	6	43,099	0.014%	2	37,297	0.005%	3.00	1.16
Total		**238**	**687,465**	**0.035%**	**96**	**399,502**	**0.024%**	**2.48**	**1.72**

Table 3

Rough categorization of Eco-patent commons technologies

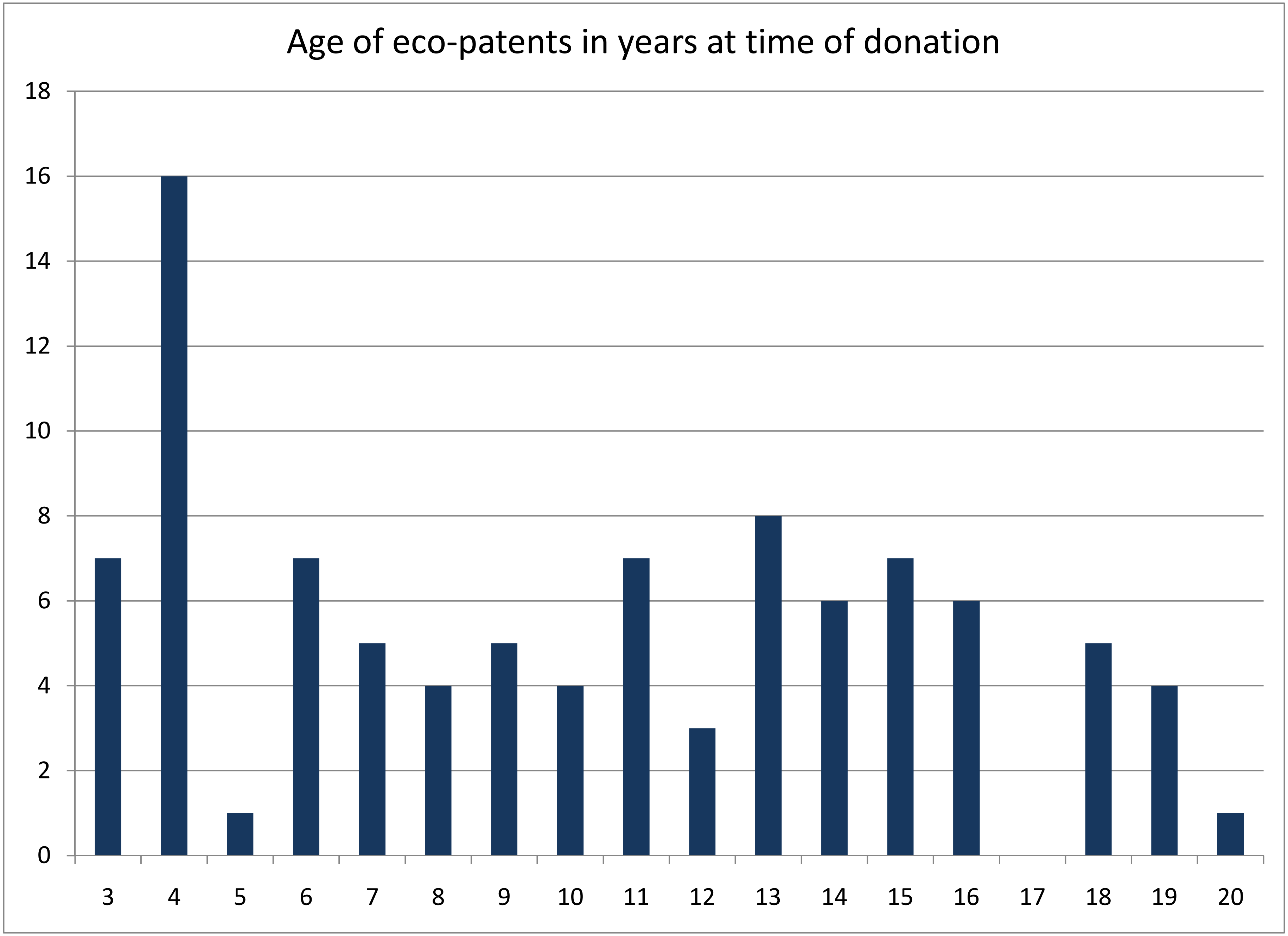
Technology	*Not in OECD sample*	*In OECD sample*	*Total*
Not clear	2	0	2
Clean manufacturing	20	2	22
Clean up soil & groundwater	0	23	23
Electric auto related	1	1	2
Energy efficiency (mostly autos)	35	5	40
Global warming (fluorocarbons)	7	0	7
Pollution	10	7	17
Recycling (mostly disks)	3	4	7
Total	**78**	**42**	**120**

Table 4: Average age in years of patent by legal status

as of April 2010*

	Number	*Share*	*Mean*	*Median*	*Q1*	*Q3*
In force	138	58.0%	11.4	12.9	7.0	15.4
Nonpayment of fees	24	10.1%	12.8	13.6	9.7	18.0
Expired	10	4.2%	17.1	18.2	17.7	18.3
Withdrawn	22	9.2%	10.3	8.4	4.7	17.7
Rejected	14	5.9%	7.3	6.2	4.4	7.8
Exam request	4	1.7%	6.7	7.2	5.2	8.3
Unexamined	8	3.4%	3.8	3.6	3.6	4.1
NA	18	7.6%	13.2	14.2	10.7	18.3
All	**238**		**11.2**	**12.5**	**6.1**	**15.8**

*Age is measured on April 1, 2010, as years since the application date of the patent.


Age of eco-patents in years at time of donation
18
16
14
12
10
8
6
4
2
0
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

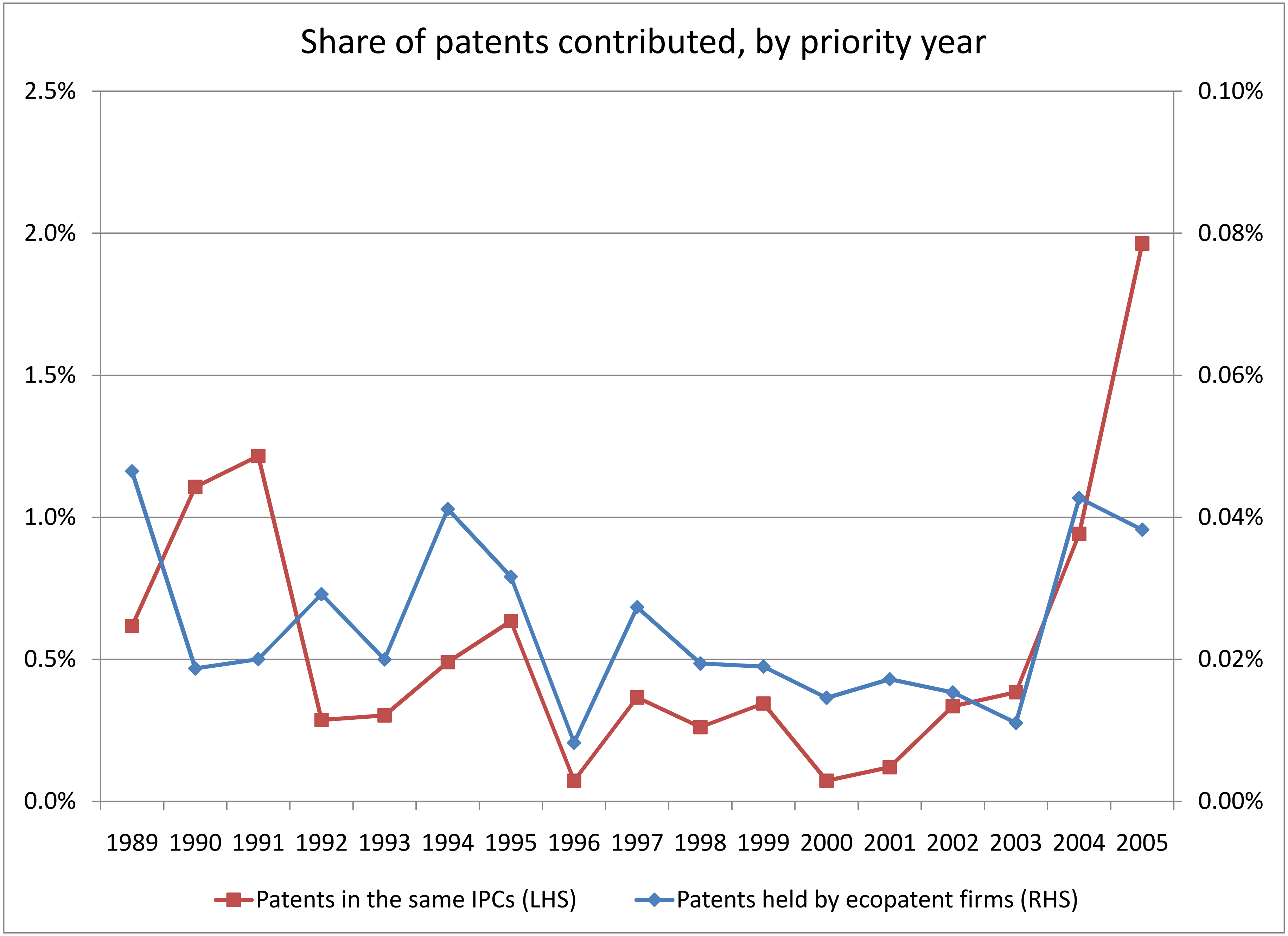

Share of patents contributed, by priority year
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
0.10%
0.08%
0.06%
0.04%
0.02%
0.00%
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Patents in the same IPCs (LHS)
Patents held by ecopatent firms (RHS)

Table A1: Patents contributed to the commons as a share of firm portfolios and patent classes by priority year

	All applications and equivalents					*Unique priorities only*				
Priority year	*Eco patents*	*Patents in the same class*	*Share*	*All pats held by eco pats firms*	*Share*	*Eco patents*	*Patents in the same class*	*Share*	*All pats held by eco pats firms*	*Share*
1989	34	2,803	1.213%	25,580	0.133%	6	972	0.617%	12,912	0.046%
1990	7	618	1.133%	29,026	0.024%	3	271	1.107%	16,028	0.019%
1991	13	924	1.407%	32,549	0.040%	4	329	1.216%	19,969	0.020%
1992	18	8,785	0.205%	32,804	0.055%	6	2,092	0.287%	20,564	0.029%
1993	7	7,181	0.097%	32,745	0.021%	4	1,321	0.303%	20,011	0.020%
1994	20	8,499	0.235%	32,936	0.061%	8	1,632	0.490%	19,441	0.041%
1995	18	2,305	0.781%	37,134	0.048%	7	1,103	0.635%	22,124	0.032%
1996	5	12,698	0.039%	40,611	0.012%	2	2,748	0.073%	24,162	0.008%
1997	10	3,826	0.261%	43,875	0.023%	7	1,912	0.366%	25,605	0.027%
1998	11	6,578	0.167%	44,667	0.025%	5	1,915	0.261%	25,757	0.019%
1999	10	2,946	0.339%	48,676	0.021%	5	1,452	0.344%	26,340	0.019%
2000	10	13,132	0.076%	51,738	0.019%	4	5,514	0.073%	27,429	0.015%
2001	10	8,568	0.117%	49,782	0.020%	5	4,158	0.120%	29,064	0.017%
2002	8	2,417	0.331%	46,389	0.017%	4	1,194	0.335%	26,088	0.015%
2003	5	1,332	0.375%	46,731	0.011%	3	781	0.384%	27,155	0.011%
2004	24	2,897	0.828%	46,211	0.052%	12	1,274	0.942%	28,097	0.043%
2005	28	959	2.920%	46,011	0.061%	11	560	1.964%	28,756	0.038%
Total	**238**	**86,468**	**0.275%**	**687,465**	**0.035%**	**96**	**29,228**	**0.328%**	**399,502**	**0.024%**

Table A2: Patent family sizes

	Number of priorities		*Average family size from docdb*		*Average family size from inpadoc*	
	Eco-patents	*Same firms*	*Eco-patents*	*Same firms*	*Eco-patents*	*Same firms*
Bosch	23	31,154	2.26	2.92	2.26	3.43
Dow	2	4,342	8.00	4.33	9.00	13.38
DuPont	14	12,729	4.50	3.71	86.57	6.26
FujiXerox	2	37,297	3.00	1.16	3.00	1.27
IBM	29	57,282	1.97	2.02	3.76	2.52
Mannesmann	1	2,673	2.00	2.60	2.00	3.28
Nokia	1	12,900	3.00	4.16	3.00	4.86
PitneyBowes	2	2027	3.50	2.47	3.50	2.90
Ricoh	1	99,821	1.00	1.15	1.00	1.53
Sony	4	119,898	1.00	1.51	4.50	1.94
Taisei	2	6,789	1.00	1.03	1.00	1.05
Xerox	15	12,590	4.87	2.51	7.27	3.05
All	**96**	**399,502**	**2.98**	**1.79**	**16.03**	**2.37**

Table A3: Patents contributed to the commons by application authority

	Application authority; equivalents included						*Priority appln authority; equivalents and mutliple priorities removed*					
Authority	*Eco patents*	*Share*	*Patents in the same class*	*Share*	*All pats held by eco pats firms*	*Share*	*Eco patents*	*Share*	*Patents in the same class*	*Share*	*All pats held by eco pats firms*	*Share*
DE Germany	45	18.9%	9,950	10.4%	76,949	11.2%	24	25.0%	2,527	8.6%	32,047	8.0%
JP Japan	34	14.3%	13,503	14.1%	282,063	41.0%	10	10.4%	2,061	7.1%	263,351	65.9%
US USPTO	75	31.5%	17,318	18.0%	142,101	20.7%	59	61.5%	24,109	82.5%	87,442	21.9%
Other	84	35.3%	55,214	57.5%	186,352	27.1%	3	3.1%	531	1.8%	16,662	4.2%
Total	**238**		**95,985**		**687,465**		**96**		**29,228**		**399,502**	

Table A4: Patent legal status by firm contributing

	Uncorrected for equivalents					*Priority patents only*				
	Number	*Granted*	*Share granted*	*In force or pending*	*Share in force*	*Number*	*Granted*	*Share granted*	*In force or pending*	*Share in force*
Bosch	52	39	75.0%	33	63.5%	23	19	82.6%	15	65.2%
Dow	9	8	88.9%	6	66.7%	2	2	100.0%	1	50.0%
DuPont	43	30	69.8%	23	53.5%	14	12	85.7%	9	64.3%
FujiXerox	6	4	66.7%	5	83.3%	2	2	100.0%	2	100.0%
IBM	53	44	83.0%	30	56.6%	29	27	93.1%	23	79.3%
Mannesmann	2	1	50.0%	1	50.0%	1	0	0.0%	0	0.0%
Nokia	3	3	100.0%	2	66.7%	1	1	100.0%	1	100.0%
PitneyBowes	7	7	100.0%	5	71.4%	2	2	100.0%	1	50.0%
Ricoh	1	1	100.0%	1	100.0%	1	1	100.0%	1	100.0%
Sony	4	4	100.0%	4	100.0%	4	4	100.0%	4	100.0%
Taisei	2	2	100.0%	2	100.0%	2	2	100.0%	2	100.0%
Xerox	56	51	91.1%	39	69.6%	15	14	93.3%	12	80.0%
All	**238**	**194**	**81.5%**	**151**	**63.4%**	**96**	**86**	**89.6%**	**71**	**74.0%**

Table: Statistics on regression variables

Simple statistics for patents owned by firms contributing eco-patents (priority years 1989-2005)

	*Mean**		*Std. Dev.**		*T-test*	*z-test*	*Minimum*		*Maximum*	
Variable	*Ecopatents*	*Other*	*Ecopatents*	*Other*	*Difference*	*Ranksum*	*Ecopatents*	*Other*	*Ecopatents*	*Other*
Number of inventors	2.142	1.465	0.604	0.555	**6.9**	**4.6**	0	0	8	28
Family size	2.393	1.497	0.545	0.414	**9.4**	**7.3**	1	1	13	69
Backward citations	2.700	0.694	1.265	1.006	**11.7**	**7.7**	0	0	48	157
Forward citations to 2010	1.748	0.862	1.132	0.956	**6.8**	**4.0**	0	0	67	642
Non-patent references	0.438	0.169	0.735	0.502	**14.1**	**3.7**	0	0	25	116
Number of IPCs	3.829	3.188	0.504	0.504	**4.0**	**2.8**	1	1	14	131
D (OECD greentech class)	0.354	0.010	0.481	0.098	**7.8**	**34.4**	0	0	1	1
Similarity measure	0.043	0.136	0.063	0.113	**-16.1**	**-9.5**	0.000	0.000	0.331	0.699
D (inventors missing)	0.125	0.149	0.332	0.356	-0.8	-0.7	0	0	1	1

*Geometric mean for the first 6 variables; standard deviation of the log of the variable.

Based on 96 observations for ecopatents and 399,502 for other patents owned by the same firms.

Simple statistics for patents in the same classes as eco-patents (priority years 1989-2005)

	*Mean**		*Std. Dev.**		*T-test*	*z-test*	*Minimum*		*Maximum*	
Variable	*Ecopatents*	*Same classes*	*Ecopatents*	*Same classes*	*Difference*	*Ranksum*	*Eco patents*	*Same classes*	*Eco patents*	*Same classes*
Number of inventors	2.009	0.746	0.604	0.810	**17.9**	**5.1**	0	0	8	37
Family size	2.295	1.458	0.545	0.693	**9.1**	**3.6**	1	1	13	101
Backward citations	2.071	0.482	1.265	0.991	**12.6**	**6.8**	0	0	48	119
Forward citations to 2010	1.044	0.329	1.132	0.815	**11.1**	**6.0**	0	0	67	239
Non-patent references	0.443	0.308	0.735	0.808	**5.4**	1.6	0	0	25	117
Number of IPCs	3.744	2.171	0.504	0.744	**11.8**	**8.4**	1	1	14	159
D (OECD greentech class)	0.365	0.054	0.484	0.227	**7.0**	**13.3**	0	0	1	1
D (inventors missing)	0.094	0.416	0.293	0.493	**-12.0**	**-6.4**	0	0	1	1

*Geometric mean for the first 6 variables; standard deviation of the log of the variable.

Based on 96 observations for ecopatents and 29,228 observations for others in the same classes.

Determinants of the probability that a firm contributes a patent to the ecopatents commons

399,598 observations (96 = 1) , priority year 1989-2005

	Coefficient	*Std. error*		*Coefficient*	*Std. error*		*Coefficient*	*Std. error*	
Log number of inventors	0.045	0.115		0.077	0.094		0.080	0.090	
Log family size	0.179	0.153		0.147	0.142		0.131	0.142	
Log backward citations	0.078	0.105		0.060	0.095		0.063	0.095	
Log forward citations to 2008	-0.017	0.031		-0.007	0.030		-0.015	0.028	
Log non-patent references	-0.009	0.040		-0.001	0.039		0.002	0.043	
Log number of IPCs	-0.151	0.064	**	-0.118	0.056	**	-0.179	0.053	***
Similarity measure	-2.533	0.859	***	-2.993	0.928	***			
Dummy for OECD greentech class	0.997	0.221	***						
Dummy for missing # inventors	-0.410	0.672		-0.406	0.669		-0.400	0.646	
Priority year dummies	yes			yes			yes		
IPC (1) dummies	yes			yes			yes		
Firm dummies	yes			yes			yes		
Pseudo R-squared	0.272			0.218			0.195		
Log likelihood	-652.42			-700.26			-721.49		

Heteroskedastic standard errors, clustered by firm.

Determinants of the probability that a patent in an ecopatent class is contributed to the commons

29,324 observations (96 = 1) , priority year 1989-2005

	Coefficient	*Std. error*		*Coefficient*	*Std. error*	
Log number of inventors	0.157	0.061	***	0.151	0.061	**
Log family size	0.067	0.068		0.037	0.070	
Log backward citations	0.199	0.049	***	0.204	0.047	***
Log forward citations to 2008	0.122	0.044	***	0.110	0.043	**
Log non-patent references	-0.133	0.060	**	-0.139	0.058	**
Log number of IPCs	-0.541	0.067	***	-0.548	0.066	***
Dummy for OECD greentech class	0.642	0.126	***			
Dummy for missing # inventors	-0.676	0.197	***	-0.667	0.187	***
Priority year dummies	yes			yes		
IPC (1) dummies	yes			yes		
Pseudo R-squared	0.228			0.207		
Log likelihood	-497.79			-511.28		

Heteroskedastic standard errors.